Long-Run Impacts of In-Utero Ramadan Exposure: Evidence from Administrative Tax Records

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Abstract

Using Ramadan fasting as a natural experiment, we estimate the long-run impacts of in-utero environment on labor market outcomes. We exploit administrative tax return data comprising the universe of tax filers containing 66 birth cohorts. We document that in-utero Ramadan shock experienced in the middle period of pregnancy depresses earnings of the exposed individuals by at least 3 percent. Exposed individuals are more likely to be self-employed and are systematically under-represented at the top of the income distribution. Using nationally representative survey data we show that our results are unlikely to be driven by selective timing of conception or birth seasonality.

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I Introduction

Gaps in children's health, cognitive development, and socio-emotional skills appear early and persist in later life (Cunha & Heckman, 2007). The fetal origins literature traces the roots of these gaps in the health and nutritional environment humans experience before birth, in different pregnancy sub-periods (Gluckman & Hanson, 2004; Almond *et al.*, 2018). Nine months in utero is one of the most critical periods in human skill formation and even mild shocks during this period can leave lasting imprints, shaping future abilities and health trajectories—and thereby the likely path of earnings (Almond & Currie, 2011).

Establishing causal links between in-utero environment and later-life outcomes is not straightforward. For starters, the shocks commonly used to identify these links—nutritional deprivation, disease, stress etc.—are mild and therefore may not leave strong visible markers. This measurement problem is accentuated further by the fact that outcomes are observed a long time after the shock, when the effects may have been dampened by compensatory parental investment. To overcome these challenges, it is essential that one measures outcomes with precision and has sufficient power to detect even small changes in outcomes across differentially exposed groups. Second, shocks to in-utero environment are rarely exogenous, being intricately linked with the socioeconomic status of parents and thus the likely path of offspring's earnings. For example, shocks such as famine, disease, and hunger disproportionately affect poor than rich families.

In this paper we overcome the latter challenge by leveraging a plausibly exogenous shock created by Ramadan fasting. Ramadan is the ninth month of the Islamic calendar, and Muslims fast during this lunar month as a religious obligation, abstaining among other things from eating and drinking from sunrise to sunset. Diminished food intake, changed sleep patterns, and heightened glucose swings resulting from fasting represent an external shock to the maternal environment developing embryo or fetus experiences for roughly four weeks. We use linked parent-child data from the Demographic and Health Survey (DHS) to establish the exogeneity of this shock. We show that parents do not time pregnancies to avoid or limit their children's in utero exposure to Ramadan fasting: there is no difference in birth rate across various months of the lunar year Ramadan follows. Nor is there any difference in the socioeconomic profile of parents of differentially exposed children. Note that we are not the first to document this exogeneity. Before us, similar result was established by

Almond & Mazumder (2011), van Ewijk (2011), and Almond *et al.* (2014) for diverse Muslim populations.

We use administrative data comprising the universe of income tax returns filed in Pakistan over the period 2007–2009 to estimate the impacts of in-utero Ramadan exposure on earnings, occupation choice, and other later life outcomes of exposed individuals. Besides reducing measurement error and contributing statistical power, which as we note above is essential for such a study, the administrative data helps us examining the treatment effects on economically relevant variables including earnings and occupational choice.

Biomedical literature documents many pathways through which maternal fasting can lead to irreversible physiological changes in the baby. The disruption of glucose—the body's main fuel—sets off the alternative metabolic process of fat burning, which though releases energy can harm the fetus through its toxic byproducts, ketones and fatty acids. These toxins, for example, have been linked to neurological impairment and cognitive deficiency (Hunter & Sadler, 1987; Rizzo *et al.*, 1991). Dietary restrictions of 14–18 hours can push a pregnant woman's body into a biochemical state otherwise seen only in prolonged episodes of starvation (Metzger *et al.*, 1982). The evidence of such "accelerated starvation" has been found among pregnant fasting women across the world (Malhotra *et al.*, 1989; Arab & Nasrollahi, 2001). But perhaps even more importantly, temporary biochemicals changes can be misconstrued by the body as cues of the postnatal world, thus wrongly predicting the long-run environment the fetus would be delivered into. Epigenetic adaptations triggered by these wrong predictions may leave the body with a physiology not suited to the postnatal world, thus hurting future trajectories of its health and other outcomes (Gluckman & Hanson, 2004). Economic literature, for example, has found that exposed individuals in later life are more likely to be disabled (Almond & Mazumder, 2011), experience heart disease and type-2 diabetes (van Ewijk, 2011), and have lower academic achievement (Almond *et al.*, 2014).

Ramadan, as we note above, follows a lunar calendar. It slowly passes through the Western calendar, advancing by 11 days each year, thus completing a full cycle in 33 years. We have 66 birth cohorts in our data and therefore can control for birth seasonality—an important confounder in this setup—nonparametrically. Our preferred specification also includes year and place of birth fixed effects. Comparing the outcomes of exposed and unexposed individuals we document four key results. First, in-utero Ramadan exposure has significant negative effect on earnings. We estimate more than 30 specifications but in no case can reject the hypothesis that the Ramadan exposure in any of the pregnancy months has a significant effect on earnings. Second, the effect size varies with the pregnancy month of exposure, with individuals exposed in months 3–8 being the worst affected. Earnings of these individuals are nearly 3 percent lower than the unexposed. Third, exposed individuals are more likely to be self-employed than employees and are underrepresented in the top of the income distribution. Using nationally representative survey data we show that the occupational choice of the exposed individuals likely reflects their lower educational attainment. Finally, we show that the average effect size increases with exposure intensity. Since Ramadan is observed as a religious obligation, exposure is likely to be more intense for more religious families. We construct a measure for the religiousness of a family using the first name of the individual, treating the family as religious if the first name of the individual is Muhammad.

Our estimate is an intention-to-treat effect and therefore has a lower bound interpretation. Surveys of Pakistan pregnant women show that only one-third of them fast for the whole month of Ramadan. The average treatment effect of in-utero Ramadan exposure therefore can be as high as 9 percent of earnings. Since individuals born in 9 out of 12 months of a year are exposed, a back-of-the-envelope calculation shows that Ramadan fasting by pregnant Muslim women lowers output every year by at least $2.4 billion in Pakistan and $13.8 billion globally. All major religious schools of Islam allow pregnant women to delay Ramadan fasting to a period after pregnancy if they feel fasting could harm them or the baby. Despite this conditional exemption, a majority of pregnant women fast likely because of misperceptions about religious injunctions or potential harm to the child. Our estimates show that large Pareto gains can be made by targeted interventions educating women on these misperceptions.

The rest of this paper is organized as follows. Section II surveys the literature, documenting the biomedical and economic pathways through which in-utero Ramadan exposure can affect later life outcomes. Section III describes our data and section IV empirical strategy. We show in section V that our key identification assumption that Ramadan exposure is uncorrelated with parental traits is plausible. Section VI presents our results and section VII concludes.

II In-Utero Ramadan Shock and Later-Life Outcomes

Ramadan is the ninth month of the Islamic calendar. Observing fast (*sawm*) during the month is one of the five pillars of Islam. Fasting involves among other things abstaining from food and drink from sunrise to sunset and is obligatory upon every Muslim other than those who are exempt such as children, sick, and elderly. Pregnant women are not expressly exempt, but they can skip the fast if they fear it would harm them or the baby, in which case they have to make up by fasting later in the year.[1] Despite this conditional exemption, a majority of Muslim women across the world fast during pregnancy. Table A.XV lists 19 studies that estimate the fasting rate in a diverse group of countries. It shows that observance is the norm among pregnant Muslim women, with the fasting rate ranging between 70 and 90 percent in the high-powered studies. Importantly, these studies also highlight widespread misperceptions about the nature of the Ramadan fast and its health impacts. For example, Mubeen *et al.* (2012) report that 88 percent of the surveyed women believe that fasting during pregnancy is essential and 59 percent perceive no harm from doing so.

Pregnancy is one of the most critical periods in human skill formation. Diurnal fasting during this period can disrupt the supply of nutrients to the child. Changed eating and sleeping patterns may also result in glucose swings, lack of sleep, and stress.[2] Biomedical literature has documented many pathways through which this may leave the child with lower cognitive and noncognitive skills. These pathways have been documented in detail in earlier literature (see for example Almond *et al.*, 2014). Here we give a brief overview of these pathways.

II.A Biological Mechanisms

A steady supply of glucose in the mother's blood is vital for the healthy development of the child. Dietary restrictions disrupt the supply of glucose, forcing the mother's body to turn toward fat as an alternative fuel. Metabolizing fat releases energy, but its

[1]Encyclopedia of Islam, for example, writes that "The law permits relaxation ... if pregnant or nursing women fear it would be dangerous for them if they should fast" (see "Ṣawm", in: Encyclopedia of Islam, Second Edition, Edited by: P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs).

[2]Glucose swings arise from going without food for the whole day and breaking the fast with glucose-heavy food and drinks (dates, for example), which are taken as a social norm. Sleep patterns are disturbed because breakfast has to be taken before sunrise. Stress arises among other things from the concentration of activity at the end of the day when energy is at its lowest because of food deprivation.

byproducts ketones and fatty acids can be harmful. For example, their in-utero exposure has been linked to neurological impairment among animals and to diminished cognitive ability among humans (Hunter & Sadler, 1987; Rizzo *et al.*, 1991). More generally, studies find that dietary restriction of only 14–18 hours can push a pregnant woman's body into a biochemical state—measured in terms of metabolic fuels and hormone levels in the blood—otherwise seen only in starvation (Metzger *et al.*, 1982). Such "accelerated starvation" can arise when the mother skips breakfast after a night without food, but happens even more rapidly when fasting takes place during daytime, as daytime activities increase the pregnant woman's already high glucose demand even further (Meis *et al.*, 1984). Evidence of accelerated starvation among Ramadan-fasting women has been found in West Africa, the UK, and Iran (Malhotra *et al.*, 1989; Arab & Nasrollahi, 2001).

Biochemical changes in the mother's blood also inform the fetus of the external environment it would be delivered into. Based on these cues, it may reprogram itself, acquiring traits that would give it survival advantage in the predicted environment (Gluckman & Hanson, 2004). This process, known as predictive adaptive responses (PAR), is shown in Figure I. If the environmental cues turn out to be correct, the reprogrammed traits would maximize the offspring's chance of reaching the productive age, but importantly if they turn out to be incorrect, the body's physiology would not be suited to the environment, hurting its long-term outcomes. For example, in the case of a diminished flow of nutrients from the placenta the fetus may come to expect a postnatal world with a limited supply of food. It may then reconfigure itself accordingly, slowing down metabolism and making other epigenetic adaptations to lower the body's energy requirements permanently. But if the postnatal world turns out to be one with rich food availability, the reprogrammed traits—higher fat storage, greater insulin resistance, lower muscle mass—would worsen the child's health trajectory, exposing it to obesity, hypertension, and heart disease in later life. Fetal programming is a sensitive process, and animal studies have shown that even mild nutritional changes lasting for only a few days can trigger it.[3]

To see how fetal programming may influence the child's cognitive endowment at birth, we need to examine the key stages of neural development in detail. The human brain like other organs begins to form in the embryonic stage. This process, how-

[3]In experimental animals, exposure during pregnancy to a single dose of powerful cortisol-like drugs will program the fetus to develop hypertension and insulin resistance after birth. This is particularly evident when the exposure is relatively early in development.

ever, accelerates in weeks 8–15 of pregnancy when rapid development of the cerebral cortex, called cerebrogenesis, takes place (Otake & Schull, 1998). By the end of this period, the full number of neurons a normal human possesses gets generated (Dobbing & Sands, 1973). These newly created neurons then migrate from their proliferative zones to the neocortex—their functional site. Disturbances to neuronal migration can cause learning disorders and intellectual disabilities (Nyagu *et al.*, 2002). The second critical stage of cerebrogenesis occurs during weeks 16–25. During this stage, accelerated neuronal differentiation and synaptogenesis (creation of synapses) takes place and cerebral architecture begins to take shape (Otake & Schull, 1998). The brain also undergoes programmed cell death at this stage, which, if interrupted, could lead to mental illnesses such as schizophrenia (Saugstad, 1998). In the final stage (26+ weeks) the formation of cerebral architecture, cell differentiation, and synaptogenesis continues.

The above highlights the importance of gestation weeks 8–25 in shaping the cognitive ability of the child. During these weeks, a series of timed processes including neurogenesis, neuron migration, and early differentiation occur, which make it a particularly sensitive period for reprogramming modifications (Weinstock, 2008). This is supported by empirical studies which find that any adverse external stimuli during the period, such as exposure to nuclear radiation (Otake & Schull, 1998; Almond *et al.*, 2009), influenza (Almond, 2006; Kelly, 2011), or maternal stress (den Bergh *et al.*, 2005; Persson & Rossin-Slater, 2018) worsen the child's human capital outcomes. The last factor—maternal stress—has also been linked to behavioral and cognitive deficiencies through reprogramming of the HPA axis (Glover *et al.*, 2010).[4] Fast of 13 hours or longer produces higher levels of plasma corticotrophin-releasing hormone (CRH), indicating reprogramming of the HPA axis (Herrmann *et al.*, 2001). Similarly, Ramadan fasting is associated with elevated levels of cortisol (indicating heightened sensitivity of the HPA axis) during pregnancy (Dikensoy *et al.*, 2008). Reprogramming of the HPA axis reduces the efficiency of glucocorticoid feedback, causing extended HPA responses to stress, which in turn lead to a reduction in hippocampal volume and impaired cognitive ability (Kapoor *et al.*, 2006).

[4]The hypothalamic-pituitary-adrenal axis (HPA) is a major neuroendocrine system that controls reaction to stress and regulates many processes such as mood, emotions, and immunity.

II.B Economic Mechanisms

Health endowment at birth affects future economic outcomes through many channels. Less-endowed children lack skills, such as self-regulation, motivation, time preference, risk taking, and social competence, that limit their educational attainment and labor market opportunities. For example, people with shorter planning horizons and higher rates of time preference may invest less in themselves, acquire less education, and go on to earn less than others.

These effects have been documented by multiple studies.[5] Almond & Mazumder (2011) find that Ramadan's overlap with pregnancy lowers the birth weight of affected children. Lower birth weight has in turn been causally linked to lower educational attainment by Currie & Hyson (1999); to lower adult height, IQ, and earnings by Black *et al.* (2007); and to lower cognitive development by Figlio *et al.* (2014). A recurring theme in this literature is that the causal pathways from in-utero shocks to future outcomes run through the educational attainment channel. Almond *et al.* (2014) show that Ramadan's exposure during pregnancy lowers academic achievement at age 7: exposed students on average perform 0.05-0.08 standard deviations worse than unexposed students. A qualitatively similar result was found for in-utero Ramadan exposure by Greve *et al.* (2017), influenza exposure by Almond (2006), and nuclear radiation exposure by Almond *et al.* (2009). Other studies link prenatal shocks to later life health and labor market outcomes directly. Ramadan-exposed individuals, for example, have been found more likely to be disabled as adults (Almond & Mazumder, 2011) and suffer from poor health, especially heart disease and type-2 diabetes (van Ewijk, 2011).

The time path of human capital evolution from birth to adult life, however, is not predetermined. Parental investment into children, particularly in their early life, plays an important role in this evolution, dampening or amplifying the effects of initial shocks (Heckman, 2007). If parents, for example, invest more in less-endowed children, their capacities may recover in the postnatal period. On the other hand, if the postnatal investment does not vary or falls with the baseline human capital, the at-birth disadvantage may become irreversible or worsen. The evolution of earning capacities is also influenced by how parental and societal investments in various stages of development complement and reinforce each other (Cunha & Heckman, 2007). Capacities acquired in one period, for example, may raise the productivity of

[5] See Almond *et al.* (2018) for a recent survey.

investment at subsequent stages, or they may be cross-fertilizing in the sense that a given dimension of capacity may augment the accumulation of a different dimension.

In-utero shocks commonly exploited in the fetal origins literature are mild. Their effects, however, are measured a long time after birth when these may have been dampened by compensatory investment processes we outline above. To credibly estimate these effects, it is therefore of vital importance that one measures economically relevant variables with precision. We use administrative data comprising the universe of tax returns filed in Pakistan for our estimates. The data allow us to link current labor market outcomes with past in-utero Ramadan exposure and therefore to estimate the effects of a mild treatment with precision and high statistical power. The use of administrative data is rapidly becoming a norm in this literature, which apart from reducing measurement error helps mitigate the problem of selective attrition from surveys (Almond *et al.*, 2018). Furthermore, we are able to estimate the effect of in-utero Ramadan exposure on earnings directly, which to our knowledge has not been done before.

III Data

Our primary data source is the universe of personal income tax returns filed in Pakistan over the period 2007–2009. We measure earnings as the taxable income reported by individuals on these returns. Using unique personal identifiers, we link these returns to the Tax Register, which contains information on individual characteristics such as the date of birth, place of birth, and occupation. We do not observe the religion of a person, but Pakistan is a predominantly Muslim country where more than 97% of the population report Islam as their religion (Esposito, 2004).

We restrict our sample to individuals born between 1924 and 1989. These 66 birth cohorts cover two complete cycles of Ramadan's advance through the solar year, allowing us to control for an important confounder in our setup—birth seasonality—nonparametrically. In the data, the birth date of individuals who know their year of birth but not the exact day is coded as the 1st January of the birth year. To avoid any measurement error, we drop all observation where the reported birth day is the 1st of January. We also drop observations where the date of birth or taxable income is missing. Applying these restrictions leaves us with a sample of nearly one million observations for which we observe both the exact birth date and earnings.

We combine the exact birth date with the normal gestation length of 266 days to create our measures of Ramadan exposure. This strategy is illustrated in Figure II. The left vertical axis shows the conception date, which we calculate as the birth date minus 266. We divide individuals into twelve groups depending on the pregnancy month in which they experienced Ramadan. It is easy to see from the figure that individuals conceived in the month Ramadan began in, indicated by month 0, are partially exposed with the exposure length varying between 1 and 29 days. Compared to them, those in months -2 and -1 are not exposed and those in months 1–9 are exposed in the corresponding pregnancy month. In some specifications, we use a trimester measure of exposure, classifying individuals exposed in pregnancy months 1–3 in the first trimester, 4–6 in the second, and 7–9 in the third. Using the normal pregnancy length can create measurement error in our exposure measures if the pregnancy lasts more or less than the normal term. Note, however, that individuals classified in month -2 would be exposed only if the pregnancy term falls in the $(295, 325]$ days interval, which is an extremely unlikely event (Jukic *et al.*, 2013).[6] Given that we have more power than is usually available in such studies, our baseline category in all specifications consists of individuals classified in month -2 only and we show results for all other months separately. The measurement error in conception date is therefore not a significant concern in our setting.

In addition to the tax returns, we use data from two other sources. First, to show that parents do not time pregnancies to avoid their overlap with Ramadan, we use the nationally representative Pakistan Demographic and Health Survey. The survey is a part of the international Demographic and Health Surveys (DHS) program, which collects numbers on fertility, family planning, and maternal health in more than 60 countries. We focus on the "ever-married women" part of the survey, pooling together its three rounds carried out in 1990-1991, 2006-2007, and 2012-2013. The data allow linking mothers and children and contain information on important mother characteristics such as literacy, education, partner's education, wealth index, occupation, and house ownership. The data also contain both the month and year of birth of children, using which we create measures of their in-utero Ramadan exposure.[7] The

[6]Note that premature births cannot be classified as "not exposed". They, however, can be classified as "exposed" even when they were not exposed, and for this reason our estimates for month 9 of exposure could be underestimated. But note that in such cases we may misclassify the month of exposure but not the trimester and hence our trimester estimates are unlikely to be contaminated by this issue.

[7]The data contain the month and year of birth for all children and the day of birth for a small subset of children (8%). Where we do not observe the exact birth date, we impute it to be the 15th of the birth month and create Ramadan exposure measures using the strategy described in Figure II.

survey covers children born between 1952 and 2013 and therefore has a good overlap with our tax data.

Finally, we also use data from the Pakistan Social and Living Standard Measurement (PSLM) survey. It is a nationally representative biannual survey and we access its six rounds carried out between 2004 and 2014. Using the data we document the correlation between educational attainment and occupation choices of Pakistan workers. We use the correlation to explore causal pathways between in-utero Ramadan exposure and earnings.

IV Empirical Strategy

IV.A Specification

To examine the causal link between in-utero Ramadan exposure and later life outcomes, we exploit the plausibly exogenous variation in exposure created by the timing of pregnancy, comparing the unexposed individuals with those exposed in different pregnancy months. Specifically, we estimate the following model

$$y_{igmt} = \sum_{\mu=-1}^{9} \beta_\mu \, . \, \mathbb{1}(em_i = \mu) + \gamma_g + \eta_m + \lambda_t + \varepsilon_{igmt}, \tag{1}$$

where em_i denotes the pregnancy month of Ramadan exposure. We regress the outcome of individual i born in district g, month m, and year t on dummy variables indicating the exposure month (see Figure II for the exact definition of these dummies). We omit the baseline category consisting of *certainly unexposed* individuals, classified in month -2, and include separate dummies for other exposure months from -1 to 9. The specification includes the district, month, and year of birth fixed effects.

For some of our results we define the Ramadan exposure measure in terms of the in-utero trimester rather than the month. The model we estimate in such cases is the following

$$y_{igmt} = \alpha \, . \, \mathbb{1}\left[em_i \in \{-1, 0\}\right] + \sum_{\tau=1}^{3} \beta_\tau \, . \, \mathbb{1}(et_i = \tau) + \gamma_g + \eta_m + \lambda_t + \epsilon_{igmt}, \tag{2}$$

where et_i represents the exposure trimester. Pregnancy months 1–3 of exposure are included in the first trimester and 4–9 in the next two. Our omitted category is the same as in (1) and we combine individuals in exposure months -1 and 0 into one category. This category comprises unexposed and partially exposed individuals and we use it as a specification check on our empirical strategy.

IV.B Identification

Identification in this setup rests on the assumption that the unobserved determinants of earnings and other labor market outcomes are uncorrelated with our Ramadan exposure measures. Operationally, it implies that parents do not systematically choose the timing of pregnancy in terms of the Hijra calendar so that parental composition does not vary with children's prenatal Ramadan exposure. Because individuals in exposure months -1 are unexposed and those in group 0 are partially exposed, our both models contain built-in tests of the validity of our identification strategy. We supplement these specification checks by providing direct evidence on our identification assumption from the DHS data showing that our Ramadan exposure measures are indeed uncorrelated with parental characteristics.

Birth seasonality is an important confounder in this setup. Prior work has found that later life outcomes, such as life expectancy (Doblhammer & Vaupel, 2001) and cognitive ability (Crawford *et al.*, 2007), are associated with the season of birth of the child. Because Ramadan follows a lunar calendar, it roughly begins every year 11 days earlier than the previous year. Exploiting its slow passage through the Western calendar we can disentangle the seasonality effect from the effect of interest using the standard controls provided the data cover at least 33 birth cohorts.[8] Our data include 66 birth cohorts, which lets us control for the birth seasonality nonparametrically and credibly.

IV.C Interpretation

We do not observe if mothers of individuals in our sample observed Ramadan fasting while they were pregnant. Our estimates therefore have an intention-to-treat (ITT) interpretation. Surveys of Muslim women, however, routinely find that a majority of them do fast during pregnancy. Table A.XV lists 19 such surveys from 11 diverse countries. The two high-powered surveys from Iran and Yemen report fasting rates

[8] Ramadan's slow advance through the Western calendar can be seen by comparing the two birth cohorts shown in Figure I.

between 71 and 90 percent (Arab & Nasrollahi, 2001; Makki, 2002). These fasting rates are similar to the ones estimated from Pakistan (see the first three studies in the table). There is only a modest variation in the fasting rate over the gestation term. It declines from 77 percent in the first trimester to 72 percent in the second and 65 percent in the third (Arab & Nasrollahi, 2001). Given that the fasting rate is less than 100 percent, our ITT estimates understate the average Ramadan effect in the population, a point we come back to later in the paper. One other noticeable feature of these surveys is that many women are not aware of the optional nature of the Ramadan fast. Nor are they aware of its harmful effects on the child's health. In fact, between 67 and 88 percent of the surveyed women believe that fasting is obligatory and 59–79 percent of them perceive no harm from doing so (Joosoph *et al.*, 2004; Mubeen *et al.*, 2012).

V Selective Timing of Conception?

A critical piece of our identification strategy is that the Hijra timing of conception is uncorrelated with the determinants of the child's later life outcomes. This assumption would be violated if a selected subset of parents are able to time pregnancies in such a way to avoid their overlap with Ramadan. Before presenting evidence on this point we may emphasize that Ramadan lasts one month only and therefore avoiding its overlap with pregnancies is not straightforward: pregnancies initiated in 9 out of 12 months of a year will overlap with Ramadan at some stage. Moreover, because Ramadan follows a lunar calendar, its exact timing depends on the moon sighting and therefore is not perfectly known in advance.[9] Largely for this reason the Hijra calendar is rarely used in planning decisions either at the governmental or household level.

We now formally rule out selection in the Hijra timing of conception using the nationally representative DHS data. We begin by looking at the proportion of births by birth month, comparing the Western and Hijra calendars. The Western calendar provides a useful benchmark against which we can compare our Hijra results. Figure III illustrates these results. The birth rate shows clear seasonal pattern in terms of the Western calendar with births in summer outweighing births in winter by a significant margin. In contrast, no such pattern is visible for the Hijra calendar. The birth rate is

[9] A lunar month consists of either 29 or 30 days. In Pakistan, an official body called Central Ruet-e-Hilal Committee meets on the 29th of every lunar month to announce the sighting of the new moon. In case the new moon is not sighted on the 29th, the current lunar month is extended to have 30 days.

flat over the lunar year: births in each month nearly equal one-twelfth of total births in the year. For these results, we pool the DHS data from all three survey waves. Figure A.I shows that running the analysis separately on each survey wave produces similar fertility patterns.

No variation in the birth rate does not rule out sorting of parents of different socioeconomic status across the Hijra months of conception. To rule out selection along these lines, we use variables from the DHS data indicating the socioeconomic status of parents to examine whether any of these variables shows systematic correlation with the timing of conception. Again we begin with the Western calendar to provide a benchmark. Tables A.I-A.II show that parental characteristics are indeed correlated with children's Gregorian quarter of birth. We can reject the null that the quarter of birth coefficients are jointly insignificant at the conventional level for 19 out of 20 outcomes. No such correlation, however, exists for the Hijra timing of conception. None of the trimester coefficients in Tables I-II is distinguishable from zero at the conventional levels. Nor can we reject the null that the three trimester coefficients are jointly zero for all 20 outcomes. Together the evidence thus validates our empirical strategy, showing that the timing of conception is indeed exogenous to the preexisting determinants of children's later life outcomes. Note that we are not alone in reaching this conclusion. Before us, similar exogeneity was established for the Muslim populations of Michigan, Uganda, and Iraq by Almond & Mazumder (2011), of Indonesia by van Ewijk (2011), and of Britain by Almond *et al.* (2014).

VI Results

We now examine the effects of in-utero Ramadan exposure on earnings and other outcomes using administrative tax return data. We begin by presenting nonparametric evidence and later formalize the results through the regression-based framework.

VI.A Visual Evidence

Figure IV illustrates the relationship between earnings and in-utero Ramadan exposure nonparametrically. We divide individuals into 52 groups depending on the pregnancy week in which they were exposed to Ramadan. Individuals in groups -12 to -4 are not exposed: they were conceived after Ramadan ended and were born before the start of next Ramadan. Individuals in groups -3 to 0 are partially exposed and in groups 1–39 fully exposed though in different pregnancy weeks. The figure plots the average earnings of these 52 groups. Since a lunar year is shorter than the solar year by roughly 11 days, week 39 in our sample contains only 1 day and week −12 only 3–4 days. We fit a local-linear kernel on the binned scatter plot to highlight the shape of the earnings-exposure profile.

We find a curious, saucer-shape relationship between exposure and earnings. Average earnings fall monotonically along the horizontal axis, reaching a minimum at week 15. They start rising steadily from this point onward, finishing at virtually the level they begin from. Not only does this relationship hold for average earnings but also for the other moments of the distribution—first quartile, median, and third quartile (see the bottom panel of Figure IV). Exposure to Ramadan during pregnancy seems to have long-run effects: exposed individuals—in particular those exposed in the middle period of pregnancy—earn significantly less than the unexposed in the adult life.

Figure V refines this analysis by conditioning on the month, district, and year of birth. Formally, we estimate a version of equation (1), adding successively each of the three fixed effects into the model. We plot coefficients $\hat{\beta}_{\mu}$'s along with the 95% confidence intervals around them from these specifications. Conditioning on birth covariates, in particular the year of birth fixed effects, flattens the earnings-exposure profile considerably. No meaningful difference now exists between the unexposed individuals and those exposed in the early or final months of pregnancy. In contrast, individuals exposed in the middle period of pregnancy continue to have significantly lower earnings regardless of the controls we use.

VI.B Regression Results

Table III formalizes these results by estimating equation (1). We begin with the most parsimonious specification and successively introduce the month, district, and year of birth fixed effects, permuting among their combination in the next six columns. The sample here includes all three years 2007–2009, and we cluster standard errors at the individual level. We show below that we obtain similar results if we use each year's data separately or use more granular birth controls—time and place of birth.

Unsurprisingly, the regression results are consistent with the visual evidence. In-utero Ramadan exposure indeed has a causal effect on later life earnings. Four results from this analysis are particularly noteworthy. First, the estimated coefficients for the unexposed (month -1) and partially exposed (month 0) groups are indistinguishable from zero.[10] This shows that the Hijra timing of conception does not bear a systematic correlation with earnings, validating once again the key piece of our empirical strategy. Second, we can easily rule out that Ramadan exposure in any of the pregnancy months has no effect on adult life earnings. The null that exposure months dummies are jointly insignificant is rejected with a *p*-value close to zero. Third, exposure in pregnancy months 3–8 matters the most. The final specification, which makes the most granular comparison, shows that individuals exposed in these months earn 2–3 percent less on average than the *certainly unexposed* (our omitted category). Fourth, exposure in the final pregnancy month does not seem to matter. By that time, the fetus has already gained maturity and any incremental shocks are less likely to exert significant negative effects. The insignificant coefficient may also reflect that some individuals in month 9 are exposed for a period shorter than four weeks (please see Figure II for details).

VI.C Exposure Intensity

Table A.XV shows that a majority of Muslim women fast during pregnancy. It means we have a strong first stage in our setup, although we do not observe the fasting rate for our sample directly. The fasting data would have allowed us to go beyond the ITT to estimate the average treatment effect in the population. It would also have allowed us to see if the effect size increases with the fasting rate (the number of days a women fasts during pregnancy—the exposure intensity). Here we follow an alternative strategy to make progress on the latter point. Since Ramadan fast is observed as a religious obligation, the fasting rate must to a first order depend on how religious an individual's family was at the time they were in utero. We do not observe family religiousness directly but can construct a measure of it using the given name of the individual. Specifically, we define a family as religious if the given name of the individual is Muhammad. We presume here that religious mothers are more likely to pick a religious name for their children and are more likely to fast during pregnancy. Bifurcating our sample on the basis of this criterion, we estimate the effect size for the two groups separately. Figure VI shows these results, which are consistent with our a priori reasoning. The point estimates for the group with higher expected

[10] Recall individuals grouped in month -1 are unexposed and ones in month 0 are partially exposed (please see Figure II on how we construct these groups). The coefficient on the first group is always insignificant and on the second is insignificant in specifications with the cohort fixed effects.

fasting rate are invariably larger (negative), although the difference between the two is not always significant. The positive relationship between exposure intensity and the effect size strengthens our causal story further, linking Ramadan exposure during pregnancy to earnings in the later life.

VI.D Mechanisms

We next explore mechanisms underlying our main result. To increase power, we use equation (2) with the trimester measure of Ramadan exposure for this exercsie. We first re-estimate our earnings equation for this specification as a baseline, obtaining similar results (compare Tables IV and III). We next examine two other outcomes—occupation choice and position in the income distribution—using this alternative specification. The results are in Table V. Occupation choice is a binary variable here, indicating if the individual is an employee as opposed to being self-employed. In-utero Ramadan exposure indeed matters for occupation choice: the estimated likelihood of employment is significantly lower for individuals exposed in the first two trimesters of pregnancy (by around 0.7 percentage points or 1.25 percent) than for the unexposed group (the omitted category). Although this effect appears small in magnitude, it has the potential to explain the earnings effect we estimate. The average income of employees in our sample is 2.85 times that of the self-employed (more on this below). Having 1.25 percent fewer employees among the second-trimester group, for example, would lower the average income of that group by 2–3 percent, which roughly equals the reduced form effect we estimate for earnings. Perhaps driven by this occupation choice the proportion of top earners also falls with the Ramadan exposure, especially for those exposed in the second trimester (see the next four columns of the table).

Choosing employment in place of entrepreneurship (self-employment) is commonly associated with having lower ability to bear risk. But in developing countries employment, especially in the public sector, is linked with status and hence on average attracts more able and more educated individuals. To examine this point formally, we use the PSLM data where both occupational choice and educational attainment are recorded. Table VI presents the results. We restrict the sample to working individuals who report either employment or self-employment as their occupation and regress a dummy for being an employee on an indicator that the individual attains education up to the given level or higher. Clearly, a strong correlation exists between these two variables. The propensity to be an employee rises sharply as one goes up the education ladder. For example, individuals with an undergraduate degree or higher are 14% more likely to be employees. This difference in educational attainment in turn reflects in the income people earn. Figure VII compares earnings of employees and self-employed using the tax data. The employees' distribution has a thicker right tail and first-order stochastically dominates that of the self-employed other than at the extreme bottom. Piecing together the evidence presented so far, we can construct the causal pathway linking in-utero Ramadan exposure to later-life earnings. Stressed maternal environment during pregnancy means exposed children are born with lower endowment of cognitive and non-cognitive skills. They go on to attain less education, make dominated occupational choice, and earn less income.

VI.E Robustness

Our results are robust to important identification and inference issues. Section V shows that parents do not time pregnancies to avoid Ramadan exposure. Nor does their composition differ significantly across the exposed and unexposed groups. This conclusion is further strengthened by built-in tests our estimating equations contain. They show that within the unexposed groups there are no systematic differences in terms of earnings or other outcomes depending upon their Hijra month of conception. We now run more robustness checks. We have so far controlled for birth seasonality using the month of birth fixed effects. Our sample contains 66 birth cohorts and exploiting the richness of our data we can experiment with finer controls. We can also experiment with more granular spatial controls. Tables A.III and A.IV do this, showing that our results are not sensitive to these alternative specifications. For our baseline results, we pool data for all three years (2007–2009), clustering standard errors at the individual level. Tables A.V–A.X show that similar results are obtained if we estimate our models on each year's data separately. We report these year-wise results for both our pregnancy month and trimester measures of exposure.

VI.F Heterogeneity

We explore heterogeneity in treatment effects along three dimensions. First, the epigenetic mechanisms we discussed in section II.A ensure that the body remains at its prime at least until the reproductive age. As a result, some adverse effects of the PARs do not appear till quite late in life (Gluckman & Hanson, 2004). In our setup, it means that our treatment effects would be significantly worse among the older cohorts. Table A.XI tests this hypothesis. We estimate an augmented version of equation (2), adding interactions of the Ramadan exposure dummies and an indicator that the individual belongs to an older cohort. We progressively look at cohorts older than 40 to 65 using our preferred specification that includes all three types of birth fixed effects. The results are consistent with our a priori reasoning. The point estimates of the interaction terms are almost always negative, economically meaningful, and increase monotonically with age, although we cannot rule out that the differences between young and old cohorts are statistically indistinguishable.

The length and severity of Ramadan fast vary across seasons. Pakistan is located around 2,000 miles north of the equator and its day length accordingly does not vary as much over the year as it does in other countries.[11] Also, the longer days coincide with the best weather of the year (average temperature around 15°C). In distinction to the day length, the variation in temperature across summer and winter months is unusually large in Pakistan, with temperature reaching 50°C in some parts of the country in summer. Fasting during such extreme weather is likely to have more pronounced effects than in other months.[12] Table A.XII explores heterogeneity in the treatment effect along this dimension. We indicate individuals whose in-utero exposure to Ramadan was in months May and June—the two hottest and driest months in the country—with the dummy variable *Ext Weather*. As expected, the coefficients on the interaction terms are negative and meaningful, but as earlier for our preferred specification we cannot rule out that these differences are statistically insignificant.

Parental investment, as we note earlier, can offset the negative effects of prenatal shocks. We do not observe parental income in our data and instead proxy it using the place of birth of the individual. The dummy *Major City* in Table A.XIII indicates that the individual was born in one of the three richest cities of Pakistan—Karachi, Lahore, and Islamabad. To the extent that parental income is on average higher for this group of individuals, any differential effect could capture the role of parental

[11] Pakistan's latitude is 30.3753° N. The day length remains constant at 12 hours at a latitude of 0° and varies between 0 and 24 hours at a latitude of 80°. In Pakistan, the day length varies around 3–4 hours over the year. For example, in 2021 the day length was 13 hours 27 minutes on the 21st June and 10 hours 35 minutes on the 21st December in Karachi (data from the website https://www.timeanddate.com/, retrieved on June 27, 2021).

[12] Note that Ramadan fasting involves abstaining from both food and water from sunrise to sunset. In hot and dry months, abstaining from water and other liquids becomes more important, causing dehydration and other related concerns.

investment. Clearly, incomes of these individuals are on average higher than others (see the results of the specifications where we do not control for the place of birth fixed effects) and the point estimates of the interaction terms are of expected sign, but again these differences are statistically insignificant in the more granular comparisons.[13]

VI.G Effect on Sex Ratio

One other effect of Ramadan fasting discussed in literature is that it may skew the sex ratio of exposed children toward females. Some biomedical studies suggest that low level of glucose in the mother's blood around the time of conception may favor the survival of female conceptuses (Larson *et al.*, 2001).[14] This initial difference may get amplified by selective post-birth mortality by sex. This biological mechanism, called Trivers-Willard hypothesis, has been validated by some empirical studies (Mathews *et al.*, 2008; Almond & Mazumder, 2011; van Ewijk, 2011) but not by others (Cramer & Lumey, 2010). In Table A.XIV, we investigate this question using both administrative and DHS data. Given that the uterine environment at the time of conception (rather than later in the gestation period) matters the most for this outcome, the coefficient of interest now is that of month 0.[15] We estimate equation (1) with and without controls, but in no case is the coefficient significantly different from zero. In fact, Ramadan exposure in any of the prenatal months bears no association with the sex ratio. Nutritional stress coming from fasting does not seem to favor conception or survival of a particular sex.

[13] An important caveat here is that these differences could also reflect differences in fasting rate across locations. The positive difference, for example, may reflect that the fasting rate on average is lower in major cities.

[14] There are well-described examples of environmentally-determined sex ratios in species such as the red deer (Gluckman & Hanson, 2004). In general, under stressed nutrition conditions, more females are born, as the survival of the species depends on the number of fetuses that reproduce in later life, which is female-dependent. As conditions improve more males are born. No conclusive evidence, however, exists about whether such environmental influences also occur in humans.

[15] According to the Trivers–Willard hypothesis when conditions are favorable, it is more advantageous for a mother to produce males. Since the sex of the offspring is determined at conception, the usual interpretation for this is that sex ratio adjustment takes place primarily around conception (Mathews *et al.*, 2008). Skewed sex ratios, however, may also arise from selective mortality by sex after birth.

VI.H Discussion

How large is the effect we estimate? The literature on returns to education estimates that one additional year of education raises labor income in later life by around 6% (Angrist & Keueger, 1991). In-utero exposure to Ramadan in the middle period of pregnancy is thus equivalent to having half a year less of education. For two reasons this understates the true cost of exposure. First, our estimate is an intention-to-treat effect. To the extent the fasting rate among pregnant women is less than 100 percent, the average treatment effect must be higher than our estimate. According to the three surveys we list in Table A.XV, more than 80 percent of Pakistani pregnant women fast for at least one day in Ramadan and around 30–40 percent fast for the whole month. Assuming that the treatment effect is homogeneous in the population, based on this data the true effect of in-utero Ramadan exposure on earnings could be as high as 9 percent.

Second, the adverse effects of prenatal shocks, as we note in section II.B, are mitigated if parents make compensatory investment in their children's human capital in the postnatal period (Cunha & Heckman, 2007). The reduced form effect in such cases understates the biological effect (Royer, 2009), a point true in general but perhaps more so in our setting. Our sample comprises the top earners of the country only.[16] To the extent that labor market outcomes persist across generations, parents of individuals in our sample must on average have been high earners themselves (Restuccia & Urrutia, 2004). They would therefore have faced milder constraints in their ability to invest in their offspring's human capital, offsetting any labor market disadvantage they were born with.

What is the size of the macro output loss implied by the micro estimates we report? Table IV shows that Individuals born in 9 out of 12 months of a year have lower earnings because of their in-utero Ramadan exposure. Assuming that labor earnings comprise two-thirds of the GDP of the country, our estimates imply an output loss of at least $2.3 billion in Pakistan each year.[17] In 2020, Muslim population

[16]The income tax exemption threshold in developing economies is generally large. As a result, only top earners (top 5–10 percentiles) are required to file a tax return. Since our data consist of tax returns, they capture the top end of the income distribution only.

[17]This back-of-the-envelope figure is based on the following calculation. Using estimates in Table IV, we assume that on average in-utero Ramadan exposure lowers earnings of the exposed individuals by 1.5 percent. Pakistan roughly has a GDP of US$300 billion. We arrive at the $2.3 billion figure by multiplying $300 billion with 0.67 (labor's share in the GDP) and 0.75 (individuals born in 9 out of 12 months are affected) and 0.015 (the effect size).

in the world was around 1.91 billion.[18] Extrapolating the Pakistani estimates to the global population translates into an annual loss of roughly $13.8 billion. This represents a lower bound on the output loss given that our estimate is a lower bound on the average treatment effect. Ramadan fasting by pregnant Muslim women, as we note above, is not obligatory: all four religious schools of Islam allow delaying it to a time after pregnancy. High rates of fasting during pregnancy thus largely reflect misperceptions about religious injunctions and its harmful long-run effects. In principle, therefore, large Pareto gains can be made by reducing these misperceptions through targeted awareness programs. It bears emphasizing, however, that challenging people's cherished beliefs—involving their notions of morality, religion, and identity—evokes strong emotional response (Bénabou & Tirole, 2016). To the extent that misperceptions about Ramadan fasting are "protected" beliefs, people may be averse to acquiring new information and may not update their priors on the receipt of new information to the extent a rational learner will.

Finally, the causal pathway we suggest for our treatment effect is consistent with prior work. Based on the occupation choice of exposed individuals and its strong correlation with educational attainment we argue that the earnings effect we document likely mediates through the education channel. The exposed individuals are born with lower cognitive ability; they accordingly attain less education, choose dominated occupations, and earn less than the unexposed. Importantly for us, Almond *et al.* (2014) document a similar negative relationship between Ramadan exposure and academic performance of the Pakistani and Bangladeshi expatriate population in the UK. They find that the test scores of the exposed students, measured at age 11, are 0.06–0.08 standard deviations lower than the unexposed. Such negative relationship between in-utero shocks and educational attainment was found for other types of shocks, such as exposure to disease and radiation, as well (see section II.B for details). The negative effect on earnings operating through the education channel may be exacerbated by the long-run effects of fasting on health documented by van Ewijk (2011) and Almond & Mazumder (2011). We do not observe health outcomes in our data and therefore cannot estimate this channel separately.

[18] See Religious Composition by Country, 2010–2050 by Pew Research Center. We accessed this data on 30th April 2021 from https://tinyurl.com/rz3ucvds.

VII Conclusions

We use Ramadan fasting as a natural experiment to document long-run impacts of in-utero health and nutrition shocks on labor market outcomes. We show that the exposed individuals on average have lower earnings relative to the unexposed. The size of the effect varies with the gestation month of exposure with individuals exposed in months 3–8 of pregnancy being the worst affected. Exposed individuals make dominated occupation choice and are less likely to be in the top of the income distribution. We rule out that our results are driven by selective timing of conception, creating variations in parental composition across the exposed and unexposed groups. Parents of the exposed group have on average similar characteristics as the parents of the unexposed group. Nor do we find any evidence that parents systematically time pregnancies to avoid or limit in-utero exposure of their children. Finally, we find that the effect size increases with the exposure intensity. Individuals belonging to religious families in general have a larger treatment effect. Our back-of-the-envelop calculations show that Ramadan fasting by pregnant women causes at least a $2.3 billion loss of output every year in Pakistan and $13.8 billion globally. This implies that large Pareto gains can be made by investing in targeted awareness programs, educating families on the conditional exemption from Ramadan fasting available to pregnant women and its harmful effects on the children's human capital.

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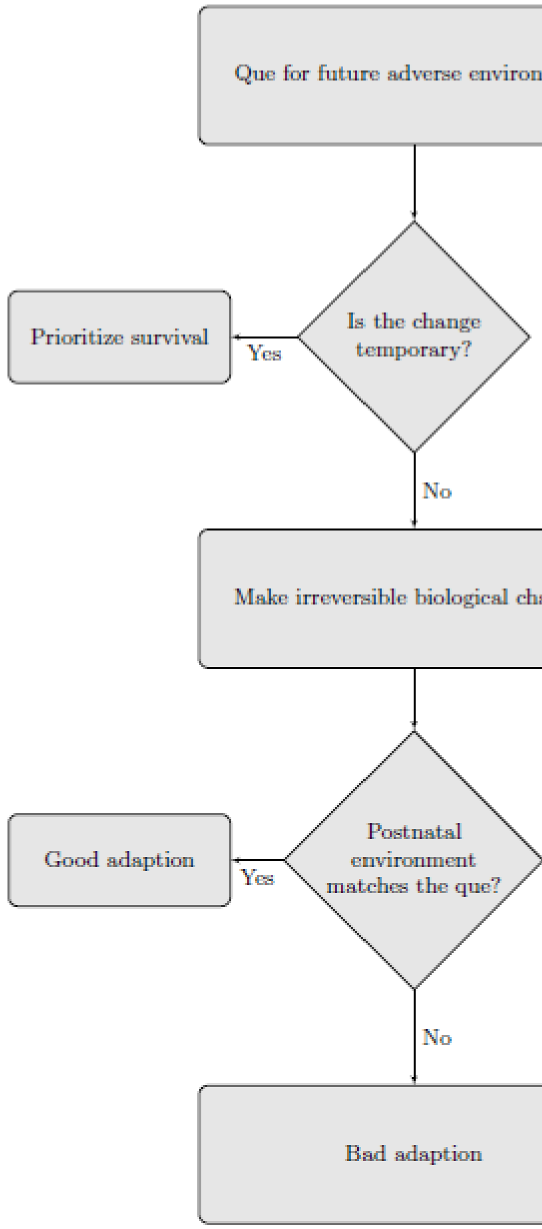
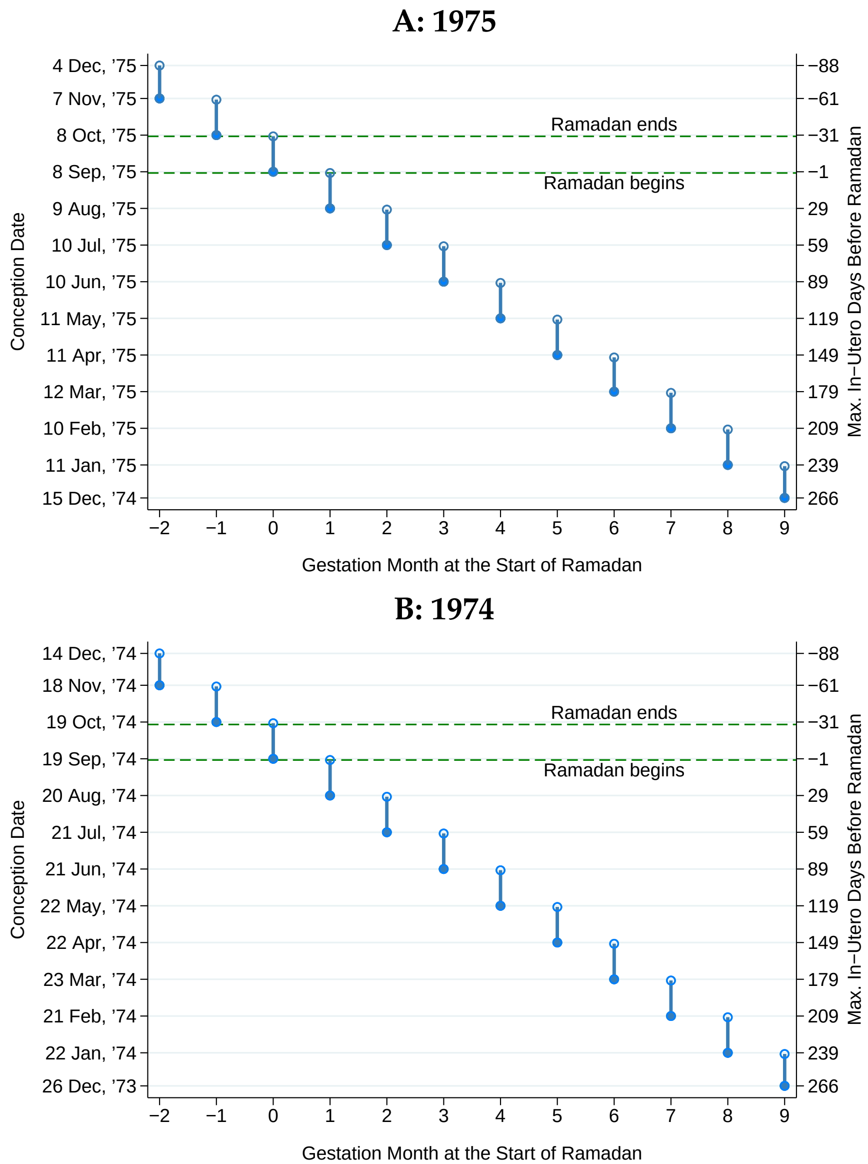
FIGURE I: **PREDICTIVE ADAPTIVE RESPONSES**



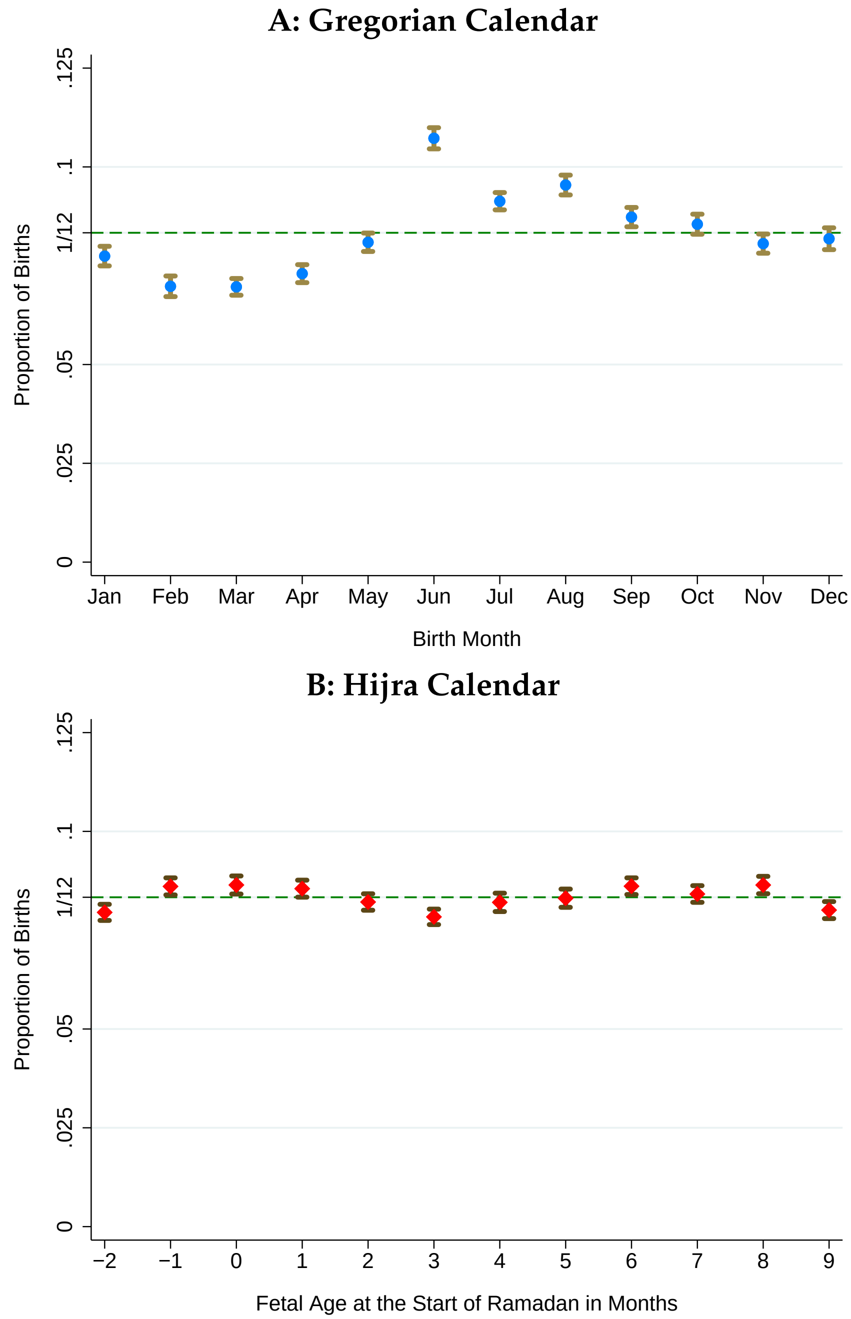
Notes: Predictive Adaptive Responses are the processes through which environmental changes in the early developmental phase lead to long-term irreversible changes in the physiology and physical phenotype of the developing embryo/fetus (Gluckman & Hanson, 2004). The figure shows how this process works. Upon receipt of an environmental cue, the body initiates short-term adaptive responses for immediate survival. In case the cue persists, the embryo/fetus uses it to predict the long-term environment it would be delivered into. Based on this prediction, it makes strategic adaptive choices that offer survival advantage till the reproductive age in the predicted environment. Such adaptations are good if the predicted environment matches the actual postnatal environment and maladaptations if it does not.

FIGURE II: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**



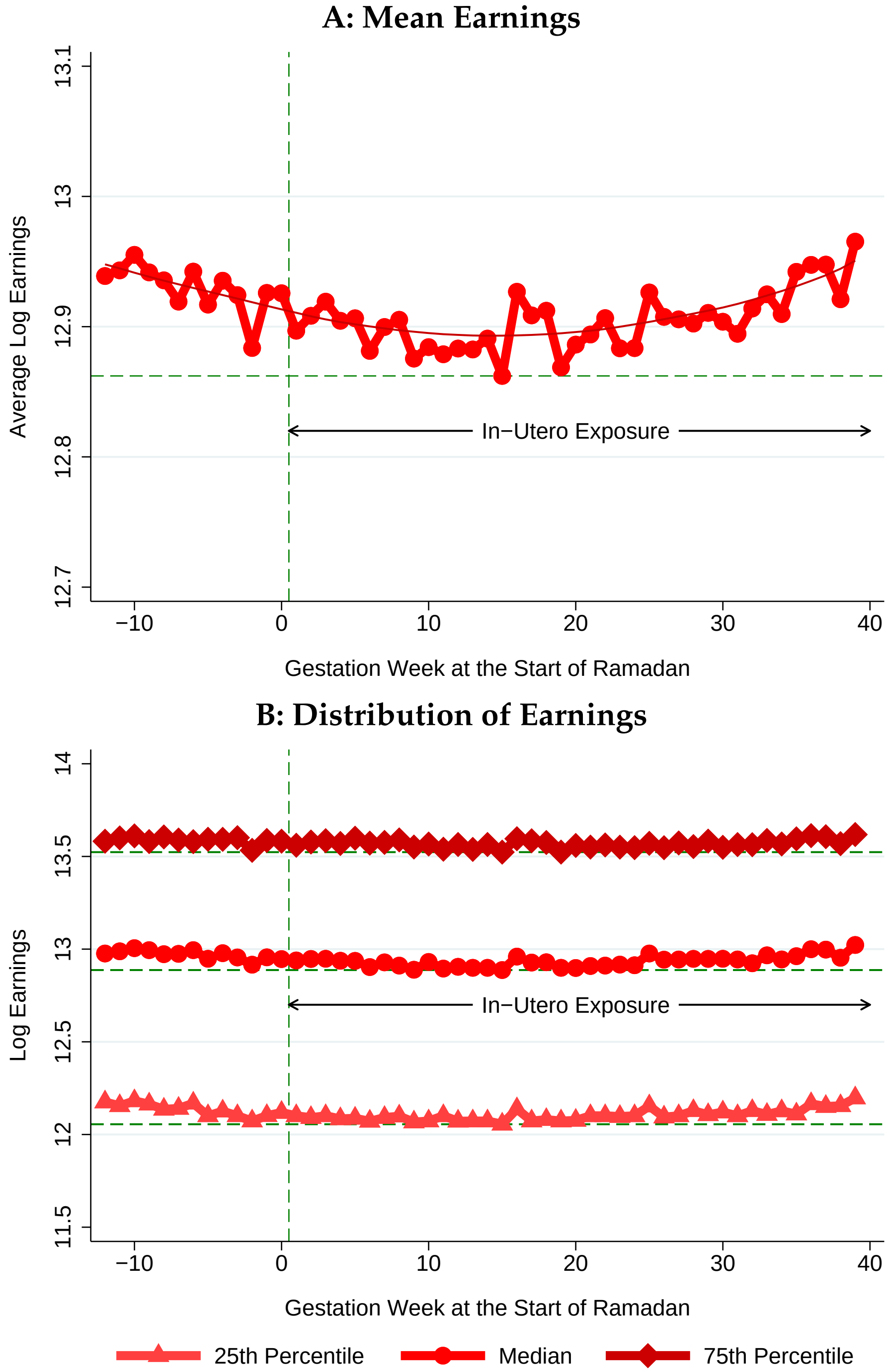
Notes: The figure illustrates how we define our Ramadan exposure measures. The top panel shows the cohort born between 7th September 1975 and 26th August 1976. The left y-axis indicates the conception date of these individuals, which is defined as the birth date minus the normal gestation length of 266. The relevant Ramadan for this cohort began on 7th September and ended on the 7th October of 1975. Individuals in Gestation Month 0, indicated along the horizontal axis, were conceived between 1 and 31 days after the beginning of Ramadan. They therefore are partially exposed. In comparison, individuals in groups -2 and -1 are unexposed and in groups 1–9 are fully exposed. The right y-axis indicates the maximum days the individual has been in utero at the beginning of Ramadan. The bottom panel repeats the exercise for the preceding cohort.

FIGURE III: **BIRTH SEASONALITY**



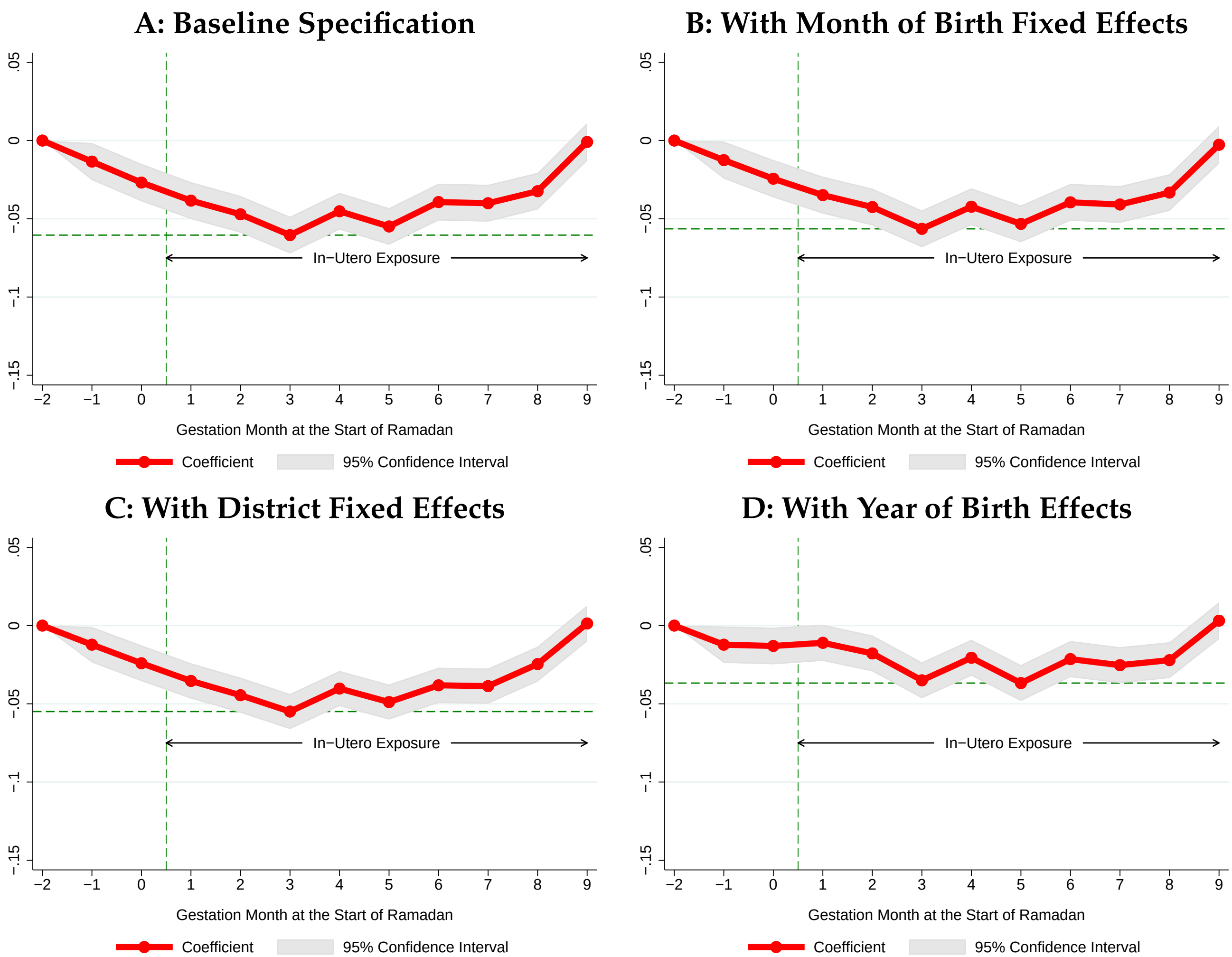
Notes: The figure explores seasonality in births over both the Western and Islamic calendar years. We regress a dummy variable indicating the month of birth on a constant using the DHS data. We run one such regression for each month and plot the estimated coefficients and 95% confidence intervals around them from these regressions. The regressions are weighted by sampling weights so that the results are nationally representative. The top panel defines the month of birth as the Gregorian calendar month the person was born in. The bottom panel, on the other hand, defines the month of birth according to the Islamic Hijra calendar. To maintain consistency, we divide people here into the same twelve month groups we used in Figure II. Persons in the month 0 for example are persons conceived in the month Ramadan began in. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012.

FIGURE IV: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**



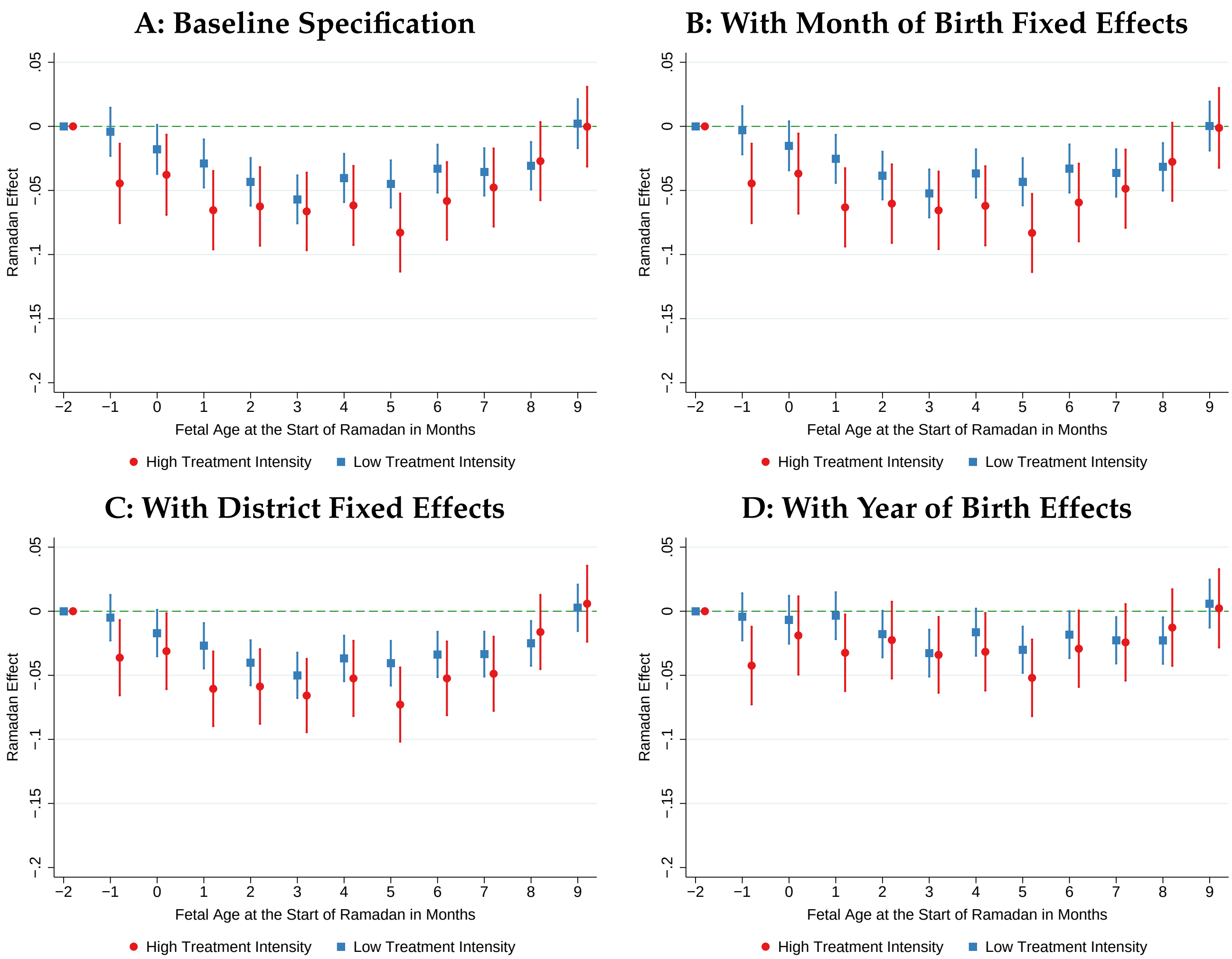
Notes: The figure shows the raw relationship between earnings and Ramadan exposure. We divide individuals into 52 groups depending upon the gestation week they experience the Ramadan in. Individuals in week 0 are conceived in the same week Ramadan began in. For example, in 1975 Ramadan began on the 8th of September. Individuals conceived between 8–14 September are included in group 0. We find conception date by subtracting the normal gestation length of 266 days from the exact date of birth. Individuals in weeks $[1, 40]$ are exposed, in weeks $[-3, 0]$ are partially exposed, and other are not exposed. Panel A shows average earning of individuals in each group and Panel B the other three moments of the distribution. Earnings here represent the taxable income reported by the individual in their tax return filed in the period 2007–2009.

FIGURE V: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**



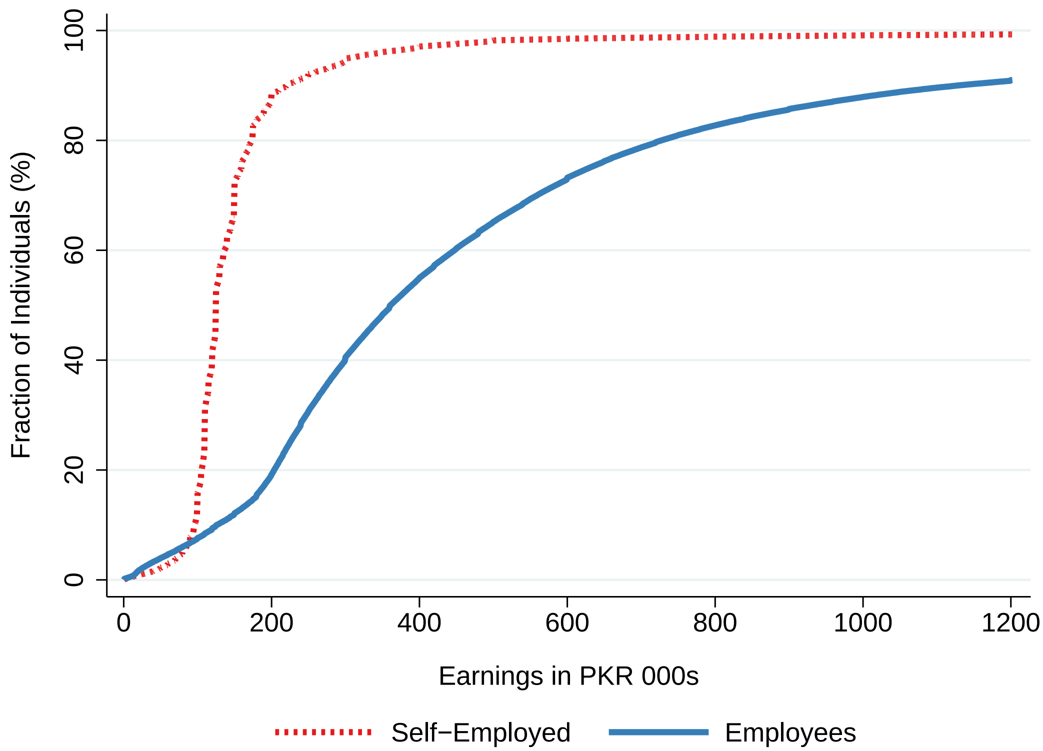
Notes: The figure explores the relationship between earnings and Ramadan exposure. We divide individuals into 12 groups depending upon the gestation month they experience the Ramadan in. Individuals in week 0 are conceived in the same month Ramadan began in. For example, in 1975 Ramadan began on the 8th of September. Individuals conceived between 8th September and 7th October are included in group 0. We find conception date by subtracting the normal gestation length of 266 days from the exact date of birth. Individuals in months $[1, 9]$ are exposed, in month 0 are partially exposed, and other are not exposed. We estimate a version of equation (1) and plot the coefficients $\hat{\beta}_{\mu}$'s along with the 95% confidence interval around them. We progressively introduce our three main sets of control: month of birth fixed effects in Panel B; district of birth fixed effects in Panel C; and year of birth fixed effects in Panel D. The sample includes all tax returns filed in 2007–2009. The horizontal dashed line indicates the minimum $\hat{\beta}_{\mu}$ from the regression, showing the gestation month of exposure group we estimate the strongest negative effect for.

FIGURE VI: IN-UTERO RAMADAN EXPOSURE AND EARNINGS



Notes: The figure investigates if the effect size varies with the intensity of exposure. We divide our sample into two groups. The first group, which we call High Exposure Intensity group, comprises individuals whose given name is Muhammad. We treat the name as a proxy for the religiousness of the family, arguing that mothers of these individuals are more likely to have fasted during pregnancy. The other groups comprises all other individuals. We estimate equation (1) separately for the two groups and plot the coefficients $\hat{\beta}_{\mu}$'s along with the 90% confidence interval around them from these regressions. We progressively introduce our three main sets of control: month of birth fixed effects in Panel B; district of birth fixed effects in Panel C; and year of birth fixed effects in Panel D. We treat all English variants of the Urdu name Muhammad—Mohammad, Muhammed, and Mohammed—as the same.

FIGURE VII: **EMPLOYEES VS. SELF-EMPLOYED**



Notes: The figure plots the cumulative distribution function of earnings separately for the self-employed and employees. The sample here is the same as in our other analyses (for example Table III), comprising the tax returns filed in the period 2007–2009.

TABLE I: **SELECTION IN IN-UTERO RAMADAN EXPOSURE?**

In-Utero Ramadan	Literacy		Education		Partner Education		Partner Occupation		Wealth	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No Exposure	0.013*	0.007	0.003	0.000	0.001	-0.002	-0.008	-0.008	0.008	0.009
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)
First Trimester	0.002	0.006	-0.005	-0.002	0.002	0.002	-0.006	-0.005	-0.001	0.007
	(0.006)	(0.006)	(0.005)	(0.004)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Second Trimester	0.004	0.004	-0.001	-0.001	0.004	0.003	-0.009	-0.009	-0.003	0.004
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Third Trimester	0.009	0.002	0.000	-0.003	0.006	0.001	-0.003	-0.006	-0.002	0.001
	(0.007)	(0.006)	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Observations	116,555	116,555	116,656	116,656	116,542	116,542	116,656	116,656	89,287	89,287
Joint test, coefficients on trimester 1-3 equal 0:										
p-value	0.416	0.655	0.485	0.809	0.822	0.972	0.569	0.621	0.955	0.471
Mean Value	0.232	0.232	0.096	0.096	0.267	0.267	0.365	0.365	0.186	0.186
Fixed Effects:										
Month of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table rules out parental sorting across different Hijra months of conception. We estimate our equation (2) using the DHS data. The outcome variable in each of these regressions is indicated in the heading of each column. We weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Mean value of the outcome variable is indicated in the last row. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE II: **SELECTION IN IN-UTERO RAMADAN EXPOSURE?**

In-Utero Ramadan	Owns Home		Has Electricity		Owns Television		Has Refrigerator		Owns Motorcycle	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No Exposure	0.010	0.008	0.015**	0.004	-0.004	-0.012*	0.010	0.002	0.008	-0.001
	(0.008)	(0.007)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
First Trimester	-0.002	-0.007	0.011	0.002	-0.005	-0.007	0.005	0.001	0.004	0.002
	(0.008)	(0.008)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)
Second Trimester	0.008	-0.002	0.011	0.001	-0.003	-0.008	0.004	-0.001	0.008	0.002
	(0.008)	(0.007)	(0.007)	(0.006)	(0.008)	(0.007)	(0.008)	(0.007)	(0.007)	(0.006)
Third Trimester	0.002	-0.003	0.011	-0.000	-0.002	-0.011	-0.001	-0.008	0.005	-0.002
	(0.008)	(0.007)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)
Observations	39,049	39,049	116,606	116,606	116,604	116,604	116,604	116,604	116,574	116,574
Joint test, coefficients on trimester 1-3 equal 0:										
p-value	0.408	0.817	0.387	0.978	0.940	0.459	0.715	0.222	0.688	0.721
Mean Value	0.890	0.890	0.869	0.869	0.531	0.531	0.360	0.360	0.229	0.229
Fixed Effects:										
Month of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes: The table rules out parental sorting across different Hijra months of conception. We estimate our equation (2) using the DHS data. The outcome variable in each of these regressions is indicated in the heading of each column. We weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Mean value of the outcome variable is indicated in the last row. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE III: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**

Gestation Month at the Start of Ramadan	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.014	-0.013	-0.013	-0.013	-0.013	-0.011
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
0	-0.027***	-0.024**	-0.024***	-0.023**	-0.013	-0.008
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
1	-0.039***	-0.035***	-0.035***	-0.034***	-0.011	-0.005
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
2	-0.048***	-0.044***	-0.045***	-0.043***	-0.018*	-0.011
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
3	-0.061***	-0.058***	-0.056***	-0.054***	-0.035***	-0.026***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
4	-0.046***	-0.043***	-0.041***	-0.040***	-0.020**	-0.013
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
5	-0.056***	-0.054***	-0.050***	-0.050***	-0.037***	-0.030***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
6	-0.040***	-0.041***	-0.039***	-0.040***	-0.022**	-0.021**
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
7	-0.040***	-0.041***	-0.039***	-0.040***	-0.025***	-0.024***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
8	-0.032***	-0.032***	-0.024***	-0.024***	-0.022**	-0.016*
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
9	-0.000	-0.002	0.002	0.001	0.003	0.005
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.000	0.000
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE IV: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS**

In-Utero Ramadan Exposure in	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
No/Partial Exp.	-0.020**	-0.019**	-0.018**	-0.018**	-0.013	-0.009
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
First Trimester	-0.049***	-0.046***	-0.046***	-0.044***	-0.021***	-0.014**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Second Trimester	-0.047***	-0.046***	-0.043***	-0.044***	-0.026***	-0.021***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Third Trimester	-0.025***	-0.026***	-0.021***	-0.022***	-0.015*	-0.012*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Joint test, coefficients on trimester 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.005	0.028
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Individuals born two months after Ramadan (month -2) are the omitting category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE V: **IN-UTERO RAMADAN EXPOSURE AND OTHER OUTCOMES**

In-Utero Ramadan Exposure in	Employee		Income > Median		Income > 75th Percentile		Income > 90th Percentile	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No/Partial Exp.	-0.006*	-0.003	-0.017***	-0.009***	-0.007**	-0.003	-0.003	-0.002
	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)
First Trimester	-0.013***	-0.007**	-0.033***	-0.010***	-0.012***	-0.001	-0.006***	-0.001
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Second Trimester	-0.013***	-0.006*	-0.031***	-0.014***	-0.015***	-0.007***	-0.006***	-0.004**
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Third Trimester	-0.002	0.000	-0.015***	-0.008**	-0.009***	-0.005*	-0.004**	-0.003
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Observations	437,627	437,478	318,385	318,288	318,385	318,288	318,385	318,288
Joint test, coefficients on trimester 1-3 equal 0:								
p-value	0.000	0.001	0.000	0.000	0.000	0.003	0.004	0.096
Mean Value	0.563	0.563	0.414	0.414	0.186	0.186	0.069	0.069
Fixed Effects:								
Month of Birth	-	✓	-	✓	-	✓	-	✓
District of Birth	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓

Notes*:* The table reports estimates from equation (2). We regress the outcome variable on four dummies indicating the four exposure groups. The outcome variable in the first two columns is an indicator showing that the individual is an employee as opposed to a self-employed. The outcome variable in the rest of the columns is a dummy indicating that the individual earns more than the threshold given in the heading of each column. The exposure dummies are defined as earlier. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Individuals born two months after Ramadan (month -2) are the omitting category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. The sample here includes all three years 2007–2009. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE VI: **EMPLOYEES & HUMAN CAPITAL**

	Outcome: $\mathbb{1}(Employee_i = 1)$									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Minimum Education Attainment:										
< Middle School	-0.055***	-0.052***								
	(0.003)	(0.003)								
Middle School			0.055***	0.052***						
			(0.003)	(0.003)						
High School					0.110***	0.104***				
					(0.003)	(0.003)				
Undergraduate							0.137***	0.137***		
							(0.004)	(0.004)		
Postgraduate									0.158***	0.161***
									0.004	0.005
Observations	273,942	273,942	273,942	273,942	273,942	273,942	273,942	273,942	273,942	273,942
Controls:										
District of Birth FEs	-	✓	-	✓	-	✓	-	✓	-	✓
Gender FEs	-	✓	-	✓	-	✓	-	✓	-	✓
Age	-	✓	-	✓	-	✓	-	✓	-	✓

Notes: The table explores the correlation between educational attainment and occupation choice among Pakistani workers. We use data from the Pakistan Social and Living Standards Measurement survey and regress the occupation choice on the individual's educational attainment. We exclude from the sample both the unemployed and workers employed in the agriculture sector. The sample thus is restricted to workers who are either employees (dummy variable $Employee_i = 1$) or self-employed. The regressor in all these regressions is a binary variable indicating that the individual has attained at least the level of education indicated in each row. We weight these regressions by sampling weights so that the results are nationally representative. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

A Online Appendix

A.1 Definition of Variables

(*i*) **Earnings.** Taxable income reported on the tax return.

(*ii*) **Conception Date.** The exact date of birth minus 266 days.

(*iii*) **Literacy.** Takes the value 1 if the DHS surveyor classifies the mother as "can read easily" in distinction to "reads with difficulty" or "cannot read".

(*iv*) **Education.** Takes the value 1 if the mother has completed secondary school or higher.

(*v*) **Partner Education.** Takes the value 1 if the mother's partner has completed secondary school or higher.

(*vi*) **Partner Occupation.** Takes the value 1 if the mother's partner is employed in one of the following four relatively skilled occupations: (1) professional, technical or managerial; (2) clerical; (3) sales; and (4) services.

(*vii*) **Wealth.** The DHS data divide households into five categories based on their wealth: (1) poorest; (2) poorer; (3) middle; (4) richer; and (5) richest. The dummy variable Wealth indicates that the household belongs to the top category.

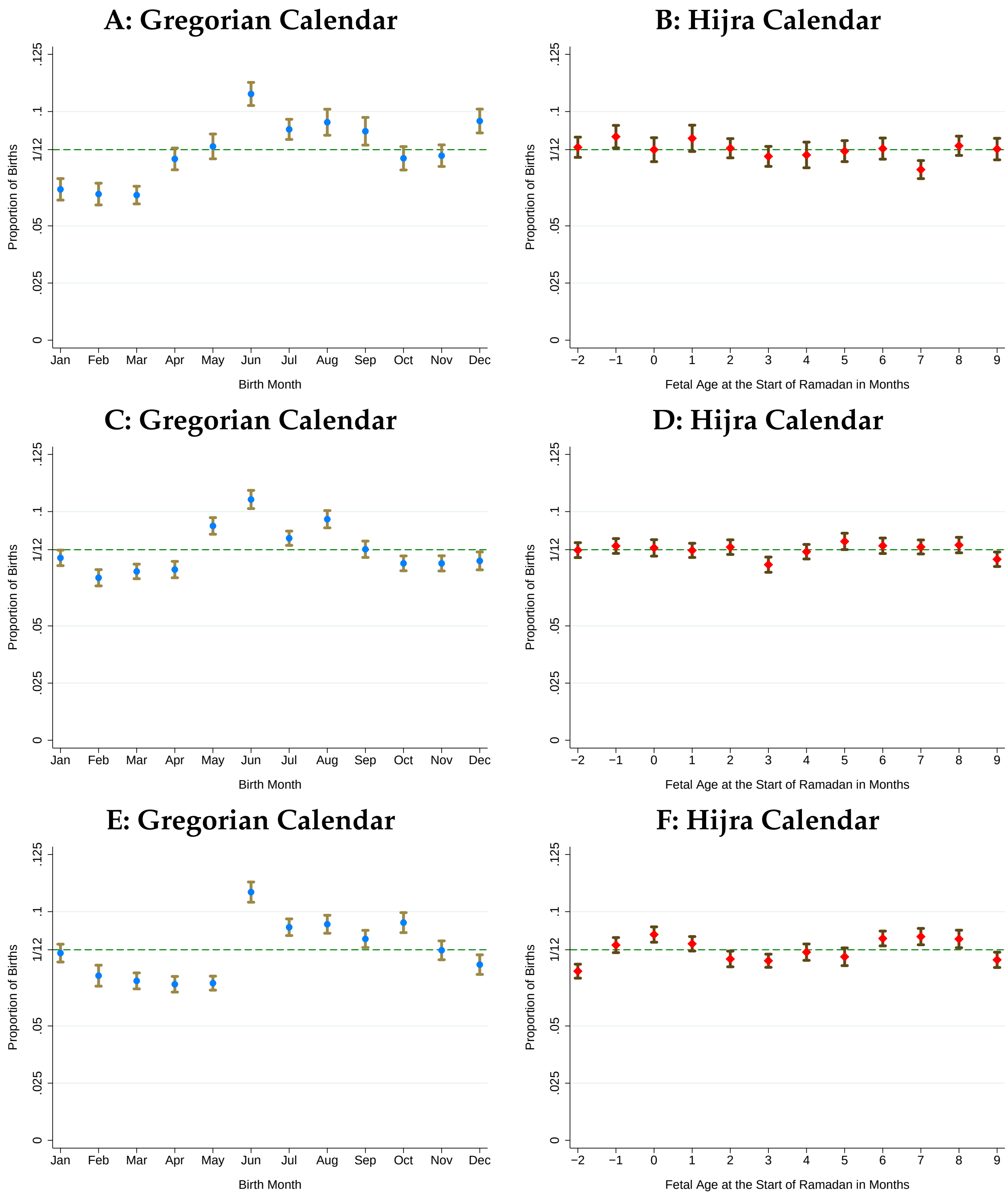
(*viii*) **Owns Home etc.** Takes the value 1 if the mother lives in an owned or rent-free house as opposed to a rented mortgaged house. Other such variables such as "Owns Television" are self-explanatory.

(*ix*) **Middle School.** The variable is from the PSLM data indicating that the respondent has completed at least ten years of education, obtaining classification called "Matriculation" in Pakistan.

(*x*) **High School.** The variable is from the PSLM data indicating that the respondent has completed at least twelve years of education.

(*xi*) **Undergraduate/Postgraduate.** The variable is from the PSLM data indicating that the respondent has completed at least an undergraduate/postgraduate degree.

FIGURE A.I: **BIRTH SEASONALITY**



Notes: The figure replicates the analysis in Figure III after separating the sample of each DHS survey wave. The top panels are based on the 1990-1991 wave, the middle on the 2006-2007 wave, and the bottom on the 2012-2013 wave. Each panel regress a dummy variable indicating the month of birth on a constant using the corresponding wave of the DHS data. We run one such regression for each month and plot the estimated coefficients and 95% confidence intervals around them from these regressions. The regressions are weighted by sampling weights so that the results are nationally representative. The LHS panels define the month of birth as the Gregorian calendar month the person was born in. The RHS panels, on the other hand, defines the month of birth according to the Islamic Hijra calendar. To maintain consistency, we divide people here into the same twelve month groups we did in Figure II. Persons in the month 0 for example are persons conceived in the month Ramadan began in.

TABLE A.I: **SEASONALITY IN GREGORIAN QUARTER OF BIRTH**

In-Utero Ramadan	Literacy		Education		Partner Education		Partner Occupation		Wealth	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Second Quarter	-0.042***	-0.029***	-0.022***	-0.014	-0.032***	-0.019	-0.026***	-0.021	-0.023***	-0.014***
	(0.005)	(0.005)	(0.003)	(0.000)	(0.005)	(0.000)	(0.006)	(0.000)	(0.005)	(0.004)
Third Quarter	-0.006	-0.006	0.002	0.002	-0.008	-0.004	-0.007	-0.006	-0.000	0.002
	(0.006)	(0.005)	(0.004)	(0.000)	(0.006)	(0.000)	(0.006)	(0.000)	(0.006)	(0.004)
Fourth Quarter	0.007	0.001	0.007*	0.005	-0.011*	-0.008	-0.002	-0.000	0.014**	0.012**
	(0.006)	(0.006)	(0.004)	(0.000)	(0.006)	(0.000)	(0.007)	(0.000)	(0.006)	(0.005)
Observations	116,555	116,555	116,656	116,656	116,542	116,542	116,656	116,656	89,287	89,287
Joint test, coefficients on Quarters 2-4 equal 0:										
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean Value	0.232	0.232	0.096	0.096	0.267	0.267	0.365	0.365	0.186	0.186
Fixed Effects:										
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table explores parental sorting across different Gregorian months of birth. We estimate a version of our equation (2), regressing the outcome indicated in the heading of each column on three quarter of birth dummies, dropping the first as the omitted category. Second Quarter dummy, for example, includes individuals born in calendar months April to June. We use the DHS data for this purpose and weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the district and year of birth as controls. Mean value of the outcome variable is indicated in the last row. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.II: **SEASONALITY IN GREGORIAN QUARTER OF BIRTH**

In-Utero Ramadan	Owns Home		Has Electricity		Owns Television		Has Refrigerator		Owns Motorcycle	
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Second Quarter	0.004	-0.003	-0.017***	-0.005	-0.037***	-0.020***	-0.030***	-0.016	-0.025***	-0.014***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.007)	(0.005)	(0.006)	(0.000)	(0.005)	(0.004)
Third Quarter	0.004	0.000	-0.017***	-0.009*	-0.017**	-0.009*	-0.003	0.003	-0.002	-0.001
	(0.007)	(0.006)	(0.007)	(0.005)	(0.007)	(0.005)	(0.006)	(0.000)	(0.005)	(0.005)
Fourth Quarter	-0.017**	-0.015**	-0.017**	-0.010**	-0.017**	-0.012**	-0.003	-0.000	0.002	-0.001
	(0.008)	(0.007)	(0.007)	(0.005)	(0.008)	(0.006)	(0.007)	(0.000)	(0.006)	(0.005)
Observations	39,049	39,049	116,606	116,606	116,604	116,604	116,604	116,604	116,574	116,574
Joint test, coefficients on Quarters 2-4 equal 0:										
p-value	0.026	0.117	0.032	0.181	0.000	0.002	0.000	0.000	0.000	0.002
Mean Value	0.890	0.890	0.869	0.869	0.531	0.531	0.360	0.360	0.229	0.229
Fixed Effects:										
District of Birth	-	✓	-	✓	-	✓	-	✓	-	✓
Year of Birth	-	✓	-	✓	-	✓	-	✓	-	✓

Notes*:* The table explores parental sorting across different Gregorian months of birth. We estimate a version of our equation (2), regressing the outcome indicated in the heading of each column on three quarter of birth dummies, dropping the first as the omitted category. Second Quarter dummy, for example, includes individuals born in calendar months April to June. We use the DHS data for this purpose and weight the regressions by sampling weights so that the results are nationally representative. Even-numbered columns include the district and year of birth as controls. Mean value of the outcome variable is indicated in the last row. For details of the variables used here see Appendix A.1. The sample here includes all three waves of the DHS that occurred in 1990, 2006, and 2012. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.III: **ALTERNATIVE BIRTH SEASONALITY CONTROLS**

Fetal Age (Months) at	Outcome: Log Earnings				
the Onset of Ramadan	(1)	(2)	(3)	(4)	(5)
-1	-0.014	-0.013	-0.013	-0.012	-0.014
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
0	-0.027***	-0.025**	-0.024**	-0.023**	-0.025**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
1	-0.039***	-0.036***	-0.035***	-0.034***	-0.035***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
2	-0.048***	-0.044***	-0.044***	-0.043***	-0.044***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
3	-0.061***	-0.058***	-0.058***	-0.057***	-0.058***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
4	-0.046***	-0.043***	-0.043***	-0.042***	-0.043***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
5	-0.056***	-0.055***	-0.054***	-0.053***	-0.052***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
6	-0.040***	-0.041***	-0.041***	-0.039***	-0.039***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
7	-0.040***	-0.042***	-0.041***	-0.040***	-0.040***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
8	-0.032***	-0.033***	-0.032***	-0.032***	-0.032***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
9	-0.000	-0.002	-0.002	-0.000	-0.002
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	832,175	832,175	832,175	832,175	832,175
Joint test, coefficients on months 1-9 equal 0:					
p-value	0.000	0.000	0.000	0.000	0.000
Fixed Effects:					
Quarter of Birth	-	✓	-	-	-
Month of Birth	-	-	✓	-	-
Week of Birth	-	-	-	✓	-
Day of Birth	-	-	-	-	✓

Notes*:* The table reports estimates from equation (1). The first column replicates the specification in the first column of Table III. The rest of the columns introduce successively more granular birth seasonality controls. In each column, the outcome variable is the log of taxable income and as earlier we report coefficients on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.IV: **ALTERNATIVE SPATIAL CONTROLS**

Fetal Age (Months) at the Onset of Ramadan	Outcome: Log Earnings (1)	(2)	(3)	(4)	(5)
-1	-0.014	-0.015	-0.013	-0.011	-0.009
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
0	-0.027***	-0.027***	-0.024***	-0.022**	-0.020**
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
1	-0.039***	-0.040***	-0.035***	-0.033***	-0.030***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
2	-0.048***	-0.052***	-0.045***	-0.043***	-0.040***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
3	-0.061***	-0.063***	-0.056***	-0.052***	-0.050***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
4	-0.046***	-0.046***	-0.041***	-0.038***	-0.035***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
5	-0.056***	-0.053***	-0.050***	-0.047***	-0.044***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
6	-0.040***	-0.041***	-0.039***	-0.037***	-0.035***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
7	-0.040***	-0.041***	-0.039***	-0.037***	-0.034***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
8	-0.032***	-0.029***	-0.024***	-0.023**	-0.021**
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
9	-0.000	0.001	0.002	0.001	0.003
	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Observations	832,175	832,136	832,096	831,926	831,873
Joint test, coefficients on months 1-9 equal 0:					
p-value	0.000	0.000	0.000	0.000	0.000
Fixed Effects:					
Province of Birth	-	✓	-	-	-
District of Birth	-	-	✓	-	-
Tehsil of Birth	-	-	-	✓	-
UC of Birth	-	-	-	-	✓

Notes*:* The table reports estimates from equation (1). The first column replicates the specification in the first column of Table III. The rest of the columns introduce successively more granular place of birth controls. In each column, the outcome variable is the log of taxable income and as earlier we report coefficients on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. The sample here includes all three years 2007–2009. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.V: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2007**

Fetal Age (Months) at	Outcome: Log Earnings					
the Onset of Ramadan	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.011	-0.012	-0.010	-0.011	-0.015	-0.014
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
0	-0.023*	-0.024*	-0.026**	-0.026**	-0.018	-0.018
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
1	-0.046***	-0.047***	-0.049***	-0.049***	-0.021	-0.023*
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
2	-0.060***	-0.061***	-0.062***	-0.062***	-0.031**	-0.030**
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)	(0.012)
3	-0.071***	-0.071***	-0.068***	-0.067***	-0.039***	-0.031***
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
4	-0.054***	-0.053***	-0.054***	-0.054***	-0.017	-0.014
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
5	-0.066***	-0.065***	-0.057***	-0.057***	-0.037***	-0.026**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
6	-0.058***	-0.057***	-0.057***	-0.057***	-0.029**	-0.027**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
7	-0.052***	-0.051***	-0.049***	-0.048***	-0.033***	-0.028**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
8	-0.044***	-0.042***	-0.036***	-0.034***	-0.034***	-0.025**
	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)
9	-0.010	-0.010	-0.010	-0.010	-0.005	-0.005
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
Observations	165,952	165,952	165,937	165,937	165,952	165,937
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.017	0.102
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). The sample here includes tax returns filed in the tax year 2007 only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. Standard errors are in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.VI: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2008**

Fetal Age (Months) at the Onset of Ramadan	Outcome: Log Earnings (1)	(2)	(3)	(4)	(5)	(6)
-1	-0.018	-0.016	-0.016	-0.016	-0.015	-0.013
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
0	-0.030***	-0.027**	-0.025**	-0.024**	-0.013	-0.005
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
1	-0.039***	-0.034***	-0.034***	-0.032***	-0.007	0.001
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
2	-0.050***	-0.044***	-0.045***	-0.043***	-0.018*	-0.009
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
3	-0.064***	-0.059***	-0.058***	-0.056***	-0.037***	-0.025**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
4	-0.047***	-0.044***	-0.040***	-0.039***	-0.022**	-0.011
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
5	-0.060***	-0.058***	-0.056***	-0.056***	-0.041***	-0.035***
	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.010)
6	-0.042***	-0.042***	-0.041***	-0.043***	-0.023**	-0.023**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)
7	-0.042***	-0.043***	-0.039***	-0.041***	-0.026**	-0.025**
	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)	(0.010)
8	-0.030***	-0.031***	-0.022**	-0.022**	-0.019*	-0.012
	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.010)
9	-0.004	-0.006	-0.001	-0.002	0.001	0.002
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Observations	313,095	313,095	313,035	313,035	313,095	313,035
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.000	0.001
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). The sample here includes tax returns filed in the tax year 2008 only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. Standard errors are in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.VII: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2009**

Fetal Age (Months) at	Outcome: Log Earnings					
the Onset of Ramadan	(1)	(2)	(3)	(4)	(5)	(6)
-1	-0.015	-0.013	-0.014	-0.014	-0.011	-0.009
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
0	-0.029***	-0.025**	-0.025**	-0.023**	-0.009	-0.004
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
1	-0.040***	-0.036***	-0.036***	-0.033***	-0.010	-0.002
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
2	-0.048***	-0.043***	-0.044***	-0.041***	-0.014	-0.006
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
3	-0.061***	-0.057***	-0.055***	-0.053***	-0.033***	-0.024**
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
4	-0.046***	-0.044***	-0.041***	-0.041***	-0.022**	-0.016
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
5	-0.050***	-0.049***	-0.044***	-0.045***	-0.033***	-0.027***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
6	-0.038***	-0.039***	-0.035***	-0.037***	-0.021**	-0.021**
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
7	-0.036***	-0.038***	-0.037***	-0.037***	-0.021**	-0.023**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
8	-0.029***	-0.030***	-0.023**	-0.024**	-0.019*	-0.016
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
9	0.005	0.003	0.007	0.007	0.007	0.008
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	353,128	353,128	353,049	353,049	353,128	353,049
Joint test, coefficients on months 1-9 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.001	0.001
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (1). The sample here includes tax returns filed in the tax year 2009 only. We regress the outcome variable—log of taxable income—on eleven Ramadan exposure dummies, omitting the reference category (month -2). Please see Figure II on how we define these exposure dummies. Standard errors are in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.VIII: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2007**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No Exposure	-0.017	-0.018	-0.018*	-0.018*	-0.017	-0.016
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
First Trimester	-0.059***	-0.060***	-0.060***	-0.059***	-0.030***	-0.028***
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Second Trimester	-0.059***	-0.058***	-0.056***	-0.056***	-0.027***	-0.023**
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Third Trimester	-0.036***	-0.035***	-0.032***	-0.031***	-0.025**	-0.020**
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	165,952	165,952	165,937	165,937	165,952	165,937
Joint test, coefficients on trimester 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.035	0.044
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from equation (2). The sample here includes tax returns filed in the tax year 2007 only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Individuals born two months after Ramadan (month -2) are the omitting category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.IX: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2008**

In-Utero Ramadan	Outcome: Log Earnings					
Exposure in	(1)	(2)	(3)	(4)	(5)	(6)
No Exposure	-0.024**	-0.021**	-0.021**	-0.020**	-0.014	-0.009
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
First Trimester	-0.051***	-0.046***	-0.046***	-0.044***	-0.021**	-0.011
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Second Trimester	-0.050***	-0.048***	-0.046***	-0.046***	-0.029***	-0.023***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Third Trimester	-0.026***	-0.027***	-0.021**	-0.022***	-0.015*	-0.012
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Observations	313,095	313,095	313,035	313,035	313,095	313,035
Joint test, coefficients on trimester 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.009	0.031
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from equation (2). The sample here includes tax returns filed in the tax year 2008 only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Individuals born two months after Ramadan (month -2) are the omitting category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.X: **IN-UTERO RAMADAN EXPOSURE AND EARNINGS – 2009**

In-Utero Ramadan Exposure in	Outcome: Log Earnings (1)	(2)	(3)	(4)	(5)	(6)
No Exposure	-0.022**	-0.019**	-0.019**	-0.018**	-0.010	-0.007
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
First Trimester	-0.050***	-0.045***	-0.045***	-0.042***	-0.019**	-0.011
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Second Trimester	-0.045***	-0.044***	-0.040***	-0.041***	-0.025***	-0.021***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Third Trimester	-0.021**	-0.023***	-0.019**	-0.019**	-0.012	-0.011
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	353,128	353,128	353,049	353,049	353,128	353,049
Joint test, coefficients on trimester 1-3 equal 0:						
p-value	0.000	0.000	0.000	0.000	0.010	0.041
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes: The table reports estimates from equation (2). The sample here includes tax returns filed in the tax year 2009 only. We regress the outcome variable—log of taxable income—on four dummies indicating the four exposure groups. Individuals exposed to Ramadan in months 1–3 of their pregnancy are included in the First Trimester group, in months 4–6 in the Second Trimester group, and in months 7–9 in the Third Trimester group. Please see Figure II on how we define the gestation month of exposure. Individuals born two months after Ramadan (month -2) are the omitting category, and individuals in months -1 and 0 are grouped together as the No/Partial Exposure category. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XI: **HETEROGENEITY IN RAMADAN EFFECT – OLD VS. YOUNG COHORTS**

In-Utero Ramadan	Old Cohort: Age >					
Exposure in	40	45	50	55	60	65
	(1)	(2)	(3)	(4)	(5)	(6)
1st Trimester	-0.009	-0.007	-0.011	-0.011	-0.012	-0.013*
	(0.010)	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)
2nd Trimester	-0.022**	-0.018**	-0.023***	-0.023***	-0.020***	-0.020***
	(0.010)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)
3rd Trimester	-0.009	-0.007	-0.010	-0.011	-0.011	-0.010
	(0.010)	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)
1st Semester × Old Cohort	-0.010	-0.020	-0.016	-0.026	-0.055	-0.073
	(0.014)	(0.014)	(0.017)	(0.023)	(0.037)	(0.054)
2nd Semester × Old Cohort	0.001	-0.007	0.009	0.016	-0.041	-0.053
	(0.014)	(0.014)	(0.017)	(0.025)	(0.039)	(0.053)
3rd Semester × Old Cohort	-0.007	-0.013	-0.012	-0.009	-0.049	-0.115**
	(0.014)	(0.014)	(0.016)	(0.024)	(0.041)	(0.057)
Observations	832,096	832,096	832,096	832,096	832,096	832,096
Fixed Effects:						
Month of Birth	✓	✓	✓	✓	✓	✓
District of Birth	✓	✓	✓	✓	✓	✓
Year of Birth	✓	✓	✓	✓	✓	✓

Notes*:* The table reports estimates from an augmented version of equation (2), where we add double interaction terms interacting the exposure month ($\mathbb{1}\left[em_i \in \{-1, 0\}\right]$) and trimester ($\mathbb{1}(et_i = \tau)$) dummies with the dummy variable Old Cohort, which takes the value 1 if the age of individual i on July 1, 2007 measured in years exceeds the cutoff indicated in the heading of each column. The sample here includes tax returns filed in the tax years 2007–2009. The outcome variable is the log of taxable income of the individual, and all specifications include the full set of month, district and year of birth fixed effects. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XII: **HETEROGENEITY IN RAMADAN EFFECT – WEATHER**

In-Utero Ramadan	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
1st Trimester	-0.045***	-0.042***	-0.041***	-0.040***	-0.024***	-0.012
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
2nd Trimester	-0.047***	-0.036***	-0.040***	-0.033***	-0.035***	-0.017**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
3rd Trimester	-0.014*	-0.012	-0.006	-0.008	-0.018**	-0.009
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
1st Semester $\times$ Ext Weather	-0.022**	-0.018*	-0.025***	-0.018*	0.016	-0.012
	(0.010)	(0.011)	(0.010)	(0.010)	(0.015)	(0.015)
2nd Semester $\times$ Ext Weather	-0.004	-0.059***	-0.021**	-0.061***	0.051***	-0.024
	(0.011)	(0.011)	(0.010)	(0.011)	(0.015)	(0.015)
3rd Semester $\times$ Ext Weather	-0.071***	-0.088***	-0.094***	-0.089***	0.014	-0.019
	(0.011)	(0.011)	(0.010)	(0.011)	(0.015)	(0.015)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from an augmented version of equation (2), where we add double interaction terms interacting the exposure month ($\mathbb{1}\left[em_i \in \{-1, 0\}\right]$) and trimester ($\mathbb{1}(et_i = \tau)$) dummies with the dummy variable Ext Weather. The dummy variable takes the value 1 if individual i was exposed to Ramadan while in-utero in the months May and June. These two months are the harshest months in Pakistan in terms of weather. Temperature during these two months is at its peak, reaching the level of 50 degree centigrade on some days. Dry and ultra-hot weather makes Ramadans falling on these months especially hard. The sample here includes tax returns filed in the tax years 2007–2009. The outcome variable is the log of taxable income of the individual. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XIII: **HETEROGENEITY IN RAMADAN EFFECT – LOCATION**

In-Utero Ramadan	Outcome: Log Earnings					
	(1)	(2)	(3)	(4)	(5)	(6)
1st Trimester	-0.270***	-0.267***	-0.065***	-0.064***	-0.234***	-0.022**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.008)	(0.010)
2nd Trimester	-0.256***	-0.255***	-0.051***	-0.051***	-0.234***	-0.023**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)
3rd Trimester	-0.223***	-0.221***	-0.020**	-0.020**	-0.221***	-0.012
	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)
1st Semester × Major City	0.440***	0.440***	0.038**	0.041***	0.429***	0.016
	(0.008)	(0.008)	(0.015)	(0.015)	(0.007)	(0.015)
2nd Semester × Major City	0.418***	0.415***	0.015	0.015	0.419***	0.003
	(0.008)	(0.008)	(0.015)	(0.015)	(0.007)	(0.015)
3rd Semester × Major City	0.396***	0.392***	-0.002	-0.003	0.413***	-0.000
	(0.008)	(0.008)	(0.015)	(0.015)	(0.007)	(0.015)
Observations	832,175	832,175	832,096	832,096	832,175	832,096
Fixed Effects:						
Month of Birth	-	✓	-	✓	-	✓
District of Birth	-	-	✓	✓	-	✓
Year of Birth	-	-	-	-	✓	✓

Notes*:* The table reports estimates from an augmented version of equation (2), where we add double interaction terms interacting the exposure month ($\mathbb{1}\left[em_i \in \{-1, 0\}\right]$) and trimester ($\mathbb{1}(et_i = \tau)$) dummies with the dummy variable Major City. The dummy variable takes the value 1 if the district of birth of individual i is one of the three major cities of Pakistan in terms of per-capita income—Karachi, Lahore, and Islamabad. The sample here includes tax returns filed in the tax years 2007–2009. The outcome variable is the log of taxable income of the individual. Standard errors are in parenthesis, which are clustered at the individual level. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XIV: **IN-UTERO RAMADAN EXPOSURE AND SEX RATIOS**

Gestation Month at the Start of Ramadan	Tax Data (1)	Tax Data (2)	DHS Data (3)	DHS Data (4)
-1	0.002	0.003	-0.006	-0.005
	(0.002)	(0.002)	(0.009)	(0.009)
0	-0.001	0.001	0.002	0.005
	(0.002)	(0.002)	(0.009)	(0.010)
1	0.000	0.003	0.011	0.012
	(0.002)	(0.002)	(0.009)	(0.009)
2	-0.004*	-0.001	0.002	0.003
	(0.002)	(0.002)	(0.010)	(0.010)
3	-0.002	0.001	0.000	0.000
	(0.002)	(0.002)	(0.009)	(0.009)
4	-0.003	0.000	-0.001	-0.001
	(0.002)	(0.002)	(0.009)	(0.009)
5	-0.003	-0.000	0.002	0.002
	(0.002)	(0.002)	(0.009)	(0.009)
6	-0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.009)	(0.009)
7	-0.000	0.000	0.000	0.001
	(0.002)	(0.002)	(0.010)	(0.010)
8	-0.002	-0.002	-0.001	-0.000
	(0.002)	(0.002)	(0.009)	(0.009)
9	-0.001	-0.001	0.003	0.004
	(0.002)	(0.002)	(0.009)	(0.009)
Observations	437,145	437,122	116,656	116,656
Mean Value	0.109	0.109	0.483	0.483
Fixed Effects:				
Month of Birth	-	✓	-	✓
District of Birth	-	✓	-	✓
Year of Birth	-	✓	-	✓

Notes*:* The table estimates the effects of in-utero Ramadan exposure on the sex ratio. We estimate our equation (1) using an indicator that individual i is a female as the outcome variable. The first two columns estimate the equation using the tax return data and the last two using the DHS data. We use sampling weights for the last two specifications so that the results are nationally representative. Even-numbered columns include the month, district, and year of birth as controls. Standard errors are in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE A.XV: **FASTING RATE**

Country	Study	Main Findings
(1)	(2)	(3)
Pakistan	Masood et al. (2018)	Around 82.8% of women reported fasting during Ramadan out of a sample of 279 pregnant women in a hospital in Karachi, Pakistan. Almost 11.6% reported fasting for more than 10 days.
Pakistan	Nusrat et al. (2017)	Nearly 53% of Mulim women reported fasting during pregnancy out of a sample of 150 women who underwent pregnancy during the 2016 Ramadan and attended a clinic in Karachi, Pakistan; 30% reported fasting for the whole month and 38% believed that fasting during pregnancy is essential.
Pakistan	Mubeen et al. (2012)	Around 87.5% of women reported fasting during pregnancy out of a sample of 353 women from Sindh and Punjab, Pakistan, who had experienced pregnancy during Ramadan at least once in their life. Nearly 42.5% reported fasting for the whole month, 23.8% on alternate days, and 10.5% on weekends/holidays only. About 88% believed that fasting during pregnancy (when in good health) is obligatory and 59% perceived no harm in doing so.
Iran	Firouzbakht et al. (2013)	About 31.8% of women reported fasting during Ramadan in 2011 out of a sample of 215 pregnant Muslim women who attended health centers in Amol, Iran. Only 16% reported fasting for more than 10 days.
Iran	Ziaee et al. (2010)	Nearly 65% of women reported fasting during pregnancy out of a sample of 189 women delivering in a hospital in Tehran, Iran during the 2004 Ramadan. Around 50% reported fasting for more than 10 days (mostly in first trimester), and 31.7% for more than 20 days.
Iran	Arab & Nasrollahi (2001)	Around 71% of women reported fasting 1-9 days of their pregnancy out of 4,343 women delivering in Hamadan, Iran in 1999. Nearly 40% of respondents reported fasting for more than 20 days. Fasting rates were 77% for the first, 72% for the second, and 65% for third trimester of gestation.

TABLE A.XVI: **FASTING RATE**

Country	Study	Main Findings
(1)	(2)	(3)
Indonesia	van Bilsen et al. (2016)	Studies 187 Muslim women in a hospital in Jakarta, Indonesia, looking for the determinants of the decision to fast. Odds of fasting fall by 4% each week of pregnancy.
Iraq	Bander (2005)	Around 50.7% reported fasting for the whole month of Ramadan out of a sample of 225 women in Iraq who were in 22nd-28th week of gestation.
Singapore	Jooseph and SL. (2004)	Nearly 87% reported fasting for at least 1 day during pregnancy out of a sample of 182 Muslim women who had received antenatal care in a Singaporean hospital during Ramadan in 2001. Around 57% reported completing at least 20 days of fasting, 67% believed fasting is essential, and 79% perceived no harm in doing so.
Yemen	Makki (2002)	Almost 90% reported fasting for more than 20 days out of a sample of 2,242 women delivering in four hospitals in Sana'a City, Yemen, in 1995.
Malaysia	Salleh (1989)	Around 78.8% reported fasting out of a sample of 605 pregnant women attending a clinic in Muar, Malaysia, in 1985.
Gambia	Prentice et al. (1983)	Almost 90% of pregnant women (and all lactating women) from a village in Gambia fasted during Ramadan.
England	Petherick et al. (2014)	Nearly 43% of women reported fasting for at least one day and 14% for the full period of Ramadan out of a sample of 310 Muslim women of Asian or Asian British ethnicity giving birth in a hospital in Bradford, England, in 2010. Fasting occurred mostly in the 1st and 2nd trimester and was correlated with education and maternal age.

TABLE A.XVII: **FASTING RATE**

Country	Study	Main Findings
(1)	(2)	(3)
England	Malhotra et al. (1989)	Almost 45% reported fasting out of 44 Pakistani and Bangladeshi Muslim mothers in a hospital in Birmingham, England.
England	Eaton & Wharton (1982)	Three quarters of mothers in a hospital in Birmingham, England fasted during Ramadan.
England	Fowler (1990)	Around 56% reported they would observe the fast while pregnant out of a sample of 78 Muslim women who attended a clinic in Birmingham, England in 1989.
Netherland	Savitri et al. (2014)	Around 53.8% of Muslim women reported fasting to some extent out of a sample of 130 Muslim women from the Netherlands whose pregnancy overlapped with Ramadan in 2010. Nearly 37.7% fasted for more than half a month.
US	Lou & Hammond (2016)	Around 30% (11) reported fasting during their most recent pregnancy during Ramadan out of a sample of 37 Muslim women who visited a clinic in metropolitan Detroit, Michigan, US during Ramadan in 2013.
US	Robinson & Raisler (2005)	28 out of 32 Muslim women from Michigan, US, reported fasting during at least one pregnancy, 16 for the whole month. Participants estimated a fasting rate of 60-90% for pregnant Muslim women in their communities, but only 30-50% for American-born Muslim women.

Notes*:* The table lists studies that estimate fasting rate among pregnant Muslim women in different countries. The first column shows the country the study relates to, the second the study's citation and the third its main finding.